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VALUE CAPTURE IN TRANSIT:

The Case of the Lindenwold High Speed Line

W. Bruce Allen
Kuo-Ping Chang
David Marchetti
Joseph Pokalsky

The Wharton Transportation Program
The Wharton School
University of Pennsylvania

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16. Abstract

Value capture, in this case, is the taking of some or all of the enhanced value of property which is caused by the government's investment in a transit system.

Various studies have suggested that value capture be used to help finance transit systems. Recent studies have suggested that the value to be captured is very small and is very tightly spatially concentrated around the investment.

An interdependent set of models of modal choice, station choice, and travel savings are developed using the economic law of market areas. Such models spatially separate the auto users from the transit users, spatially separate the users of station A from the users of station B, and spatially connect the locii of all points where the user saves an equal amount of money from using transit over auto. All of these models yield hyperbolas which bend around the stations on the Line.

The station choice model is tested using auto access data for all suburban stations of the Line for a morning rush hour (13,000 observations). While a multinomial logit model is proposed to give the probability of station choice given station characteristics vis-a-vis other stations' characteristics, because such model would not run on the data set, the station chosen most often from any given location is assumed to be the preferred station for that location.

The savings model is tested by postulating that residential sales price is a function of characteristics of the property, neighborhood characteristics, distance from the CBD, and savings. Value capture is tested by examining to what degree the savings are capitalized into the selling price of the property. Over 1,300 real estate transactions from 1980 are used to test the savings model.

Conclusions are drawn concerning the use of value capture as a financing device in this context.

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VALUE CAPTURE IN TRANSIT: THE CASE OF THE LINDENWOLD HIGH SPEED LINE

by W. Bruce Allen
Professor of Public Policy and Management, Regional Science, and Transportation

Kuo-Ping Chang
PhD Student, Regional Science

David Marchetti
MS Student in Transportation

Joseph Pokalsky
MBA Student in Transportation

UNIVERSITY OF PENNSYLVANIA

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EXECUTIVE SUMMARY: Value Capture in Transit: The Case of the Lindenwold High Speed Line

Value capture, in this context, is the taking of some or all of the enhanced value of property which is caused by the government's investment in a transit system.

Various studies have suggested that value capture be utilized to help finance transit systems both from the concept of the beneficiaries should pay and from the pragmatic concept of money availability. More recent empirical and simulation studies have suggested that the value that can be captured is quite small relative to the investment value and also quite spatially concentrated adjacent to the investment.

Value capture analysis is applied to the situation of the Lindenwold High Speed Line between the Philadelphia CBD and the Southern New Jersey suburbs. The Line is a high performance (average speed 36 MPH, average rush hour headway 3.5 minutes, on-time performance over 98%), high quality (climate controlled stations and vehicles, safe), and convenient (12,000 parking spaces with good roadway access, located in the geographical center of population density of Southern New Jersey) system. Many of the riders (over 40%) state that they switched from driving and the full parking lots contain close to 12,000 cars which could have been driven to the CBD.

The Line has four stations in the Philadelphia CBD, two stations in the Camden (NJ) CBD, and seven park and ride stations in the southern New Jersey suburbs. During the weekday morning rush hour used in the analysis herein, 61.5% of the users parked their cars at the Line, 16.1% were dropped off at the Line by automobile, 7.5% came by public bus or by buses run by local apartment complexes, and 11.5% arrived by other methods, e.g., walk, bicycle, etc.

The operating ratio of the Line (operating revenues divided by operating costs) is approximately 80% making the Line one of the most successful transit systems in the United States. During several years in the early 1970's, the Line's operating revenues more than covered operating costs.

A theory of value capture is developed from the economic law of market areas. Initially, a modal split model is developed with geographic areas of auto use and transit use identified by utilizing decision variables such as fare, wait time, time on line, access/egress time and costs, auto cost, auto drive time, bridge tolls, and CBD parking costs. Station market areas are spatially identified by the use of the station decision variables, e.g., fare, access/egress time and costs, time on line, etc. These station areas take the form of hyperbolas in the theoretical analysis bending around the outlying stations. The actual station market areas are also calculated and presented herein. They tend to have the hyperbolic shape predicted by the theoretical model. Savings are defined as full auto costs less full Speed Line costs. The analysis allows the savings to be identified spatially so that the savings can be linked to particular pieces of property. The station market areas model, the modal choice model, and the savings model are all interdependent, but at least

one modal choice equation is necessary to determine savings. In the case herein, with seven suburban stations and the Philadelphia CBD, 64 market area equations exist. Because of the symmetry and the main diagonal, 28 equations are of interest. With knowledge of seven equations (including at least one Philadelphia-suburban station market area equation), all 28 equations can be determined. This, in turn, enables the determination of all savings equations.

It is hypothesized that the savings are capitalized into the value of the property. The degree to which such capitalization occurs will determine the amount which can be captured.

The modal choice, station choice, and savings models are developed and then applied to a hypothetical example which assumes a fixed lot size for properties and a fixed population in the impacted city. The relationship between savings level and the urban rent gradient is made explicit in this case and the degree of capitalization can be observed.

Because of data, time, and budget limitations, only a residential theory of value capture has been developed herein.

The models are empirically tested using primary data collected by the authors. All auto access to the Line was documented on April 1, 1980 (Census Day) by means of a license plate survey taken during the morning rush hour--6:30 AM to 9:30 AM. Users were catagorized by station used, by type (park and ride versus kiss and ride), parking lot used (pay, free, and location), and number of riders for kiss and ride. A tape was made containing the above information. Approximately 13,000 observations exist. The State of New Jersey Division of Motor Vehicles (DMV) matched each plate with its registered street address, town, make of vehicle, and year of vehicle. This gave the empirical data of what spatial locations choose what station which could be used to test the models developed herein.

The modal choice model could not be tested because the location data was not available for auto drivers to the Philadelphia CBD. It was desired to test the station choice models using the multinomial logit model. The model predicts the probability of using a given station from a given location given characteristics of that station vis a vis other stations as well as access/egress costs to/from the station to the location in question. The value of time can be calculated from the multinomial logit by dividing the time coefficient by the cost coefficient. The suburban locations utilized are the Census Tracts in which the DMV data showed that trips to the Speed Line originated in Burlington, Camden, and Gloucester counties in New Jersey. Over 200 such origins exist. Access and egress distances and times and an auto cost per mile were based on a calculation made by the Delaware Valley Regional Planning Commission. However, the data would not run on the model available (LIMDEP) and so the preferred station was assumed to be the station chosen most often from each Census Tract.

The savings model was calculated on the basis of the Speed Line cost from the preferred station of a given Census Tract subtracted from the auto cost from the same Census Tract to the Philadelphia CBD. Auto costs were calculated based on the minimum distance to the Philadelphia CBD via either the Ben Franklin or Walt Whitman bridges, bridge tolls, Center City parking costs, and time costs. Value of time was calculated based on income/family/hour data calculated from the 1980 Census and value of time as a percentage of wage rate information calculated by other authors. These calculations gave a savings level for each Census Tract.

The savings model was empirically tested with a regression model in which sales price of residential property was the dependent variable and various (approximately 20) characteristics of the property, e.g., lot size, number of bedrooms, etc., were independent variables, along with neighborhood characteristics (Census Tract information on median income levels, schooling levels, racial composition, etc.), distance from the CBD (to measure the normal urban rent gradient effect), and savings level as calculated above. Sales transaction data was collected for 1970 and 1980. For 1980, the usuable sample size was approximately 1,300 transactions.

The regression model yielded significant coefficients for the distance variables (the urban rent gradient effect), several characteristics of the property variables, no neighborhood variables, and, most importantly, the savings variable. The savings variable showed that for every dollar of daily savings, $443 was added to the value of the house. Savings levels from the Census Tracts which used the Line and had observed property value transactions in 1980 ranged from -$6.30 to +$21.28. Thus the maximum impact of the Line on properties was approximately $9,400 (the mean sales price of the sample was approximately $62,400). However, both of those savings levels are outliers. The average daily savings is approximately $10.34 which indicates that $4,581 in additional value has been added to the typical house as the result of the savings generated by the Line--about 7.34% of its value.

In the aggregate, a capture tax on all transit contributed value on the single family residential properties defined as in transit Census Tracts would yield $279.5 million. In the early 1970's, the authors estimated that a value capture tax could raise about $50 million in 1970. This is about half of the cost of constructing the Line. The Line's construction cost vastly understates the construction cost of building the Line from the ground up since the right of way already existed, as did a river crossing to Philadelphia, and tunnels and stations in Philadelphia and Camden. Thus while $50 million was about one half the cost of constructing the Lindenwold Line, it is a much smaller share of the costs of constructing the system from the beginning.

If the $100 million construction cost is inflated from 1968 dollars to 1980 dollars (by the Consumer Price Index), it represents $237 million as compared to the $279.5 million calculated herein. However, the Line utilized existing tunnels in Philadelphia and Camden, an existing crossing of the Delaware River, and an existing right of way in New Jersey. If the costs of these were included, construction costs would have been in the $820 million range in 1980. Therefore, the percentage that could have been captured, using the analysis herein, was approximately a third of the construction costs.

It must be stressed that this value capture analysis has numerous problems. One of the largest ones is the lack of a value of time locally generated by a station choice model. Another is the fact that the model only explains 40% of the variance of the sales price (not atypical for these type of models). Thus, the conclusions should be viewed as tentative on a quantitative basis. However, on a *qualitative* basis, a series of models have been developed with the capability of producing value capture numbers and have shown that, in this geographic market, a significantly large amount of value was available to be captured. It should also be stressed, however, that the time to capture the value is between when the line is announced and when the line becomes an operating reality. If the tax is instituted after the line has opened, it will only tax the windfall from those property owners who have continually occupied their homes. Anyone moving in after this time period has paid the capitalized savings to the seller of the house and taxing such individuals would tax them twice.

While property owners have been reluctant to vote approval of such "value capture" taxes on themselves, the analysis herein shows that property values in the transit capture areas do indeed experience an appreciation in value which is statistically significantly attributable to the level of travel savings made possible by the transit system examined.

I INTRODUCTION

The Lindenwold High Speed Line opened for revenue service between Lindenwold, Camden County, New Jersey and the Philadelphia Central Business District (CBD) in 1969. The Line runs 14.5 miles and provides service 24 hours a day, seven days a week. Four stations are served in the Philadelphia CBD, two in the Camden, New Jersey CBD, and seven suburban, park and ride stations exist in Camden County (See Map 1). Service frequency is every three to four minutes during the rush hours and no worse than 10 minute headways from 5:45 AM inbound until 7:20 PM outbound (and no worse than 12 minute headways until 11:56 PM outbound). Approximately 12,000 parking spaces currently exist at the seven suburban stations. At the time that the data used herein was collected (1980), there were 10,074 spaces. New Jersey Transit buses feed the stations and bike racks also exist at the stations.

The Line has automated ticket vending machines and ticket activated turnstyles. Only one operator is on the train and the stations are unpersoned. Security is provided via closed circuit television and by uniformed and plainclothes policepersons. The stations and the rail cars are climate controlled. The stations and rail cars are utilitarian and free of dirt and graffiti. The ratio of operating revenues to operating costs of the Line is approximately .8 which ranks the Line as one of the most successful transit systems in the country.

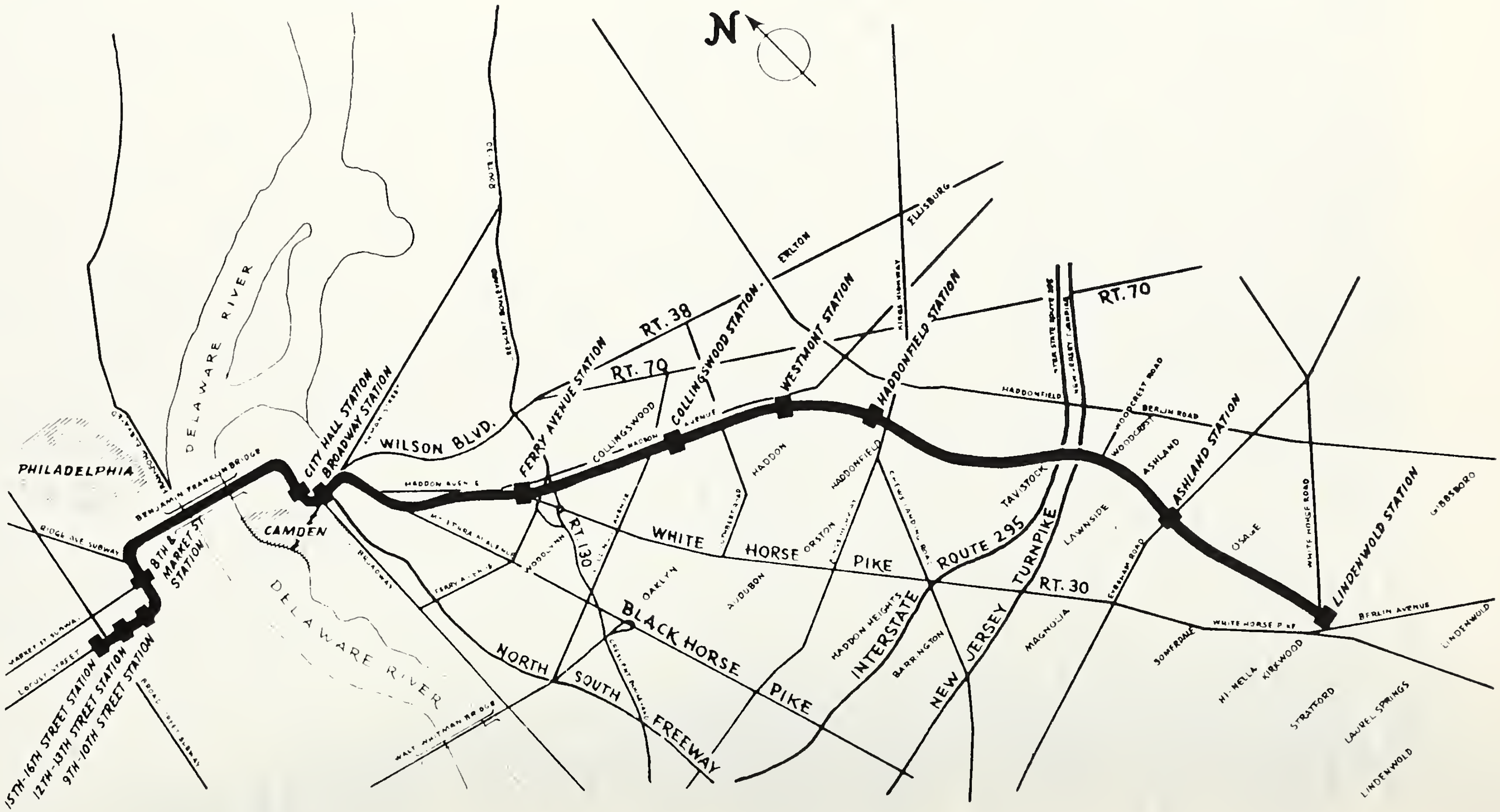
A trip from Lindenwold to Philadelphia currently costs $1.60 (plus $.25 if one parks in a pay space) one way and takes approximately 24 minutes for an average speed of approximately 36 miles per hour including station stops. This contrasts with a 45 minute drive, the auto out-of-pocket operating cost (7.87 cents per mile out of pocket costs-Delaware Valley Regional Planning Commission estimate), bridge tolls (to cross the Delaware River-.3864 cents per crossing using the commuter discount sticker), and Center City Philadelphia parking costs (average $5.45 per day).

The Speed Line is perceived to be a reliable, fast, safe, and relatively inexpensive way to travel to the Philadelphia CBD during rush hour. Approximately 20,000 riders use the system each workday which entails 40,000 rides. Most of the trips are peak oriented, i.e., work trips and most of the trips are to the Philadelphia CBD. The number of intra New Jersey trips and the number of contra-peak-direction trips are small. The peak hour users of the system tend to be well dressed white collar workers.

The 1980 Census shows 14,191 workers from Camden County that list their workplace as the Philadelphia CBD. In Burlington County (the contiguous county to the north), 5,684 Philadelphia CBD workers are found, while in Gloucester County (the contiguous county to the south), the comparable total is 3,312. Thus in the three county area, 23,187 workers work in the Philadelphia CBD. The Census also reports that 14,037 (for a 61% modal share) workers report that rail is their primary means of transportation in their journey to work in the three county area (11,941 from Camden County, 1,601 from Burlington County, and 495 from Gloucester County). It seems certain that the Speed Line is moving a significant number of

Map 1

Philadelphia - Lindenwold High-Speed Line



the South Jersey Philadelphia CBD workers into Philadelphia each day. (Other users include shoppers, students, sightseers, etc.).

The population density of the areas served by the Line tends to be quite low. In Haddonfield, the population density is approximately 4,500 per square mile. In Camden, the population density is approximately 10,000 per square mile, while in Cherry Hill, the population density is approximately 3,700 per square mile. Since these population densities are considerably less than those felt necessary to run rail rapid transit service at the levels run by the Line, the 12,000 parking spaces are utilized to create an artificially high population density surrounding the Line, i.e., utilizing the parking lot population as the basis for calculating the population density.

It is in this context of a high quality, well respected rail transit system that the value capture analysis described herein takes place.

The value capture study of the Line is organized in the following fashion. First, the data sets used to test the station choice, savings, and value capture models developed herein are described. Then the previous literature is surveyed and analyzed. The theory of modal choice, station choice, and savings used in the analysis is presented along with the parameter values used to make the analysis operational. This is followed by the empirical work on the station choice model, the demonstration of the interdependence of all three models, and a description of the derivation of the savings variable. A theoretical presentation of how the modal choice and savings models impact on the rent gradient follows. The savings capitalization relationship is demonstrated for this special case. The empirical test of savings being capitalized into property values is then presented. Finally, conclusions are drawn. Most of the theoretical model building is contained in Appendix A, with relatively simple explanatory models used in the main text.

The basic data for the empirical analysis comes from two sources. The first source is a license plate survey of all rush hour (6:30 AM to 9:30 AM) auto feeder users of the Lindenwold High Speed Line on Census day 1980 (about 78% of the Line's rush hour users either park and ride, i.e., leave their car parked at the station all day, or kiss and ride, i.e., are dropped off at the station by automobile. Shared ride information is only available for kiss and ride where virtually no multiple disembarkations were recorded. Casual empiricism suggests that the park and ride users arrive at the station at the rate of one per car). In addition, 7.5% arrive by bus and the remaining 11.5% arrive in other ways, e.g., walk, bicycle, etc. This data set is used to develop the modal split, station split, and savings (value capture) models.

The second data set consists of all arm's length residential real estate transactions conducted by the members of the Camden County Board of Realtors (the Line runs down the middle of Camden County, New Jersey) in 1970 and 1980 as well as yearly data from 1970 to 1984 for Haddonfield, a community with a station on the line. While non-member realtors and out-of-county realtors do make sales in Camden County as well as transactions between private parties which exist, most of the transactions in Camden

County will be covered by the data from the Camden County Board of Realtors. For the year 1970, approximately 1,250 observations exist. For the year 1980, 1,341 useable observations exist. Only limited transactions data on commercial and industrial properties was available from the Camden County Board of Realtors and this information was not gathered by the researchers.

The license plate survey was performed at each of the seven park and ride stations of the Lindenwold Line, i.e., Ferry Ave, Collingswood, Westmont, Haddonfield, Woodcrest, Ashland, and Lindenwold. From 6:30 AM to 9:30 AM, student volunteers at each station wrote down the license plate number of every vehicle which discharged passengers. These vehicles were put in the kiss and ride category. The number of passengers discharged was noted (usually one) as well as the type of vehicle, e.g., passenger car, taxi, feeder bus (the route number of the bus was also noted). This data was tabulated in 15 minute intervals.

After 9:30 AM, all parking lots were surveyed, i.e., license numbers taken. Each lot was coded as to location relative to the station (distance from the centroid of the lot to the station), its occupancy relative to its capacity, and as to whether it was a pay lot ($.25 for all day parking--closest to the station) or a free lot (furtherest from the station). Of the 10,074 parking places at the seven stations, 6,553 were pay, while 3,521 were free. Some (very few) metered spaces are available close to the station. These charge $.25 for eight hours and thus a commuter using such spaces would have to spend $.50 per day.

The raw information was then transferred to computer tape. This information gave license plate number, station used, kiss and ride/park and ride status, pay versus free parking, and number of passengers in kiss and ride.

This tape was then sent to the Division of Motor Vehicles of the State of New Jersey. A match was performed which gave the address to which the license plate was registered along with the make, model, and year of the car.

The tape was then returned to the researchers. For approximately 11% of the records, the license plates recorded in the on-site survey could not be matched for the following reasons: out-of-state plates, New Jersey plates registered to out-of-state corporations, incomplete addresses in the state files (which includes city missing, street name missing, street address missing), and errors in data collection, data transfer, and in the state's files. Other results showed New Jersey addresses but for locations far from the Line which may indicate visitors, etc. Only plates from Camden, Burlington (the contiguous county to the north of Camden County), and Gloucester (the contiguous county to the south of Camden County) Counties were considered in the analysis. Since the analysis herein uses the Census Tract level as the basis of observation, a by-hand match of the tape data increased the match process of the data to 95.6% as some towns only contained one Census Tract (and hence street address or name was not necessary to place the location in a tract) or a street name without an address was enough to give a tract in towns with multiple tracts. In order to obtain this 95.6% match, approximately 50% of the 89% of the records which remained for the three counties had to be processed by hand. In total, 227 Census Tracts are included in the analysis.

However, apparent matches may be incorrect. Registrations occur in New Jersey on a yearly basis. If a person moves, they technically should notify the Division of Motor Vehicles. In many cases, this is probably not done until the anniversary date of the renewal. Since the trend has been toward suburbanization, the license plate data is probably biassed toward too many close-in to the Camden area observations and too few farther-out observations, ceteris parabus.

On the other hand, auto insurance is cheaper when one is farther away from Philadelphia/Camden than when one resides closer to them. Thus some close in individuals may register their vehicles at friend's/relative's residences located farther away from Philadelphia/Camden rather than at the actual residence of the registrant in order to save on insurance premiums (although insurance companies have stated that they may not be liable if an individual has fraudulently represented himself). Thus, the license plate data is probably biassed toward too many farther-out observations and too few close-in observations, ceteris parabus.

For the latter two reasons, the station choice model may appear to misclassify results, i.e., assign an individual whose real address is near a close-in station to a farther-out station and vice versa.

The model may also appear to misclassify results due to a multiple purpose trip. Since only the Speed Line destination of the trip is known and the origin is presumed to be the registration address, the analysis herein is based on those two pieces of information. However, what is relevant is the point of origin just previous to the Speed Line destination. While this may be the registration address, for a multiple purpose trip, this last origin (workplace of a co-rider, home of a car-pooler, school location, coffee shop, etc.) may be in a station market area which is not the same as the station market area for the registration address.

Table 1 gives a summary of the data collected, by station, in the analysis. The dominance of auto feedership is shown by these statistics. Total ridership was calculated by subtracting the 6:30 AM gate counts at each station (from the automatic counter on each entry machine) from the 9:30 AM gate count. Walk-on's are a residual estimate assuming that each park and ride vehicle carries one individual (which is likely an understatement and hence walk-ons are likely overestimated).

An existing Delaware Valley Regional Planning Commission (DVRPC) model was used to give automobile travel times and auto costs from the centroid of each Census Tract to each of the speed line stations. The transit times and costs from each station were then integrated with the automobile access data to form the total cost of access from each Census Tract to the Philadelphia CBD by the Line. From this model, travel times and cost to each of the two Delaware River bridges were calculated and hence the total cost of access from each Census Tract to the Philadelphia CBD by automobile.

The real estate data was gathered from the Comparable Sales

TABLE 1

APRIL 1, 1980 SPEED LINE RUSH HOUR TRAFFIC

	6:30-9:30 ENTRANCES	KISS & RIDE	BUS	RAIL	PARK & RIDE	MAXIMUM WALK-ONS+
LINDENWOLD	4,225	709	482@	200	2,426	408
ASHLAND	2,109	300	91#		1,411	307
WOODCREST	393	89	28		325	-49^
HADDONFIELD	2,194	417	313		1,103	361
WESTMONT	1,391	195	10		964	222
COLLINGSWOOD	1,111	170	0		548	393
FERRY AVE.	2,004	279	77		1,482	166
	13,427$	2,159	1,001*	200	8,259	1,808

+ includes bike riders and multiple riders from park and ride
@ includes apartment busses in addition to New Jersey Transit
# includes Echelon Mall shuttle in addition to New Jersey Transit
$ excludes pass entrances, i.e., only revenue entrances counted
* some bus ridership transferred at the station to another bus line and thus was not feeding the line. There was no way to eliminate such riders, but the number is small.
^ error in data set

$$\frac{\text{Park \& Ride}}{\text{Entrances}} = 61.5\% \qquad \frac{\text{Kiss \& Ride}}{\text{Entrances}} = 16.1\% \qquad \frac{\text{Bus}}{\text{Entrances}} = 7.5\%$$

$$\frac{\text{Maximum Walk-Ons}}{\text{Entrances}} = 11.5\%$$

books of the Camden County Board of Realtors. These books are basically the same as the MLS "picture" books which are available for visual inspection to customers at any MLS member real estate office except that they contain the final transactions price and the number of days that the house was on the market in addition to the information normally available to the buyer, e.g., ask price, lot and structural information, etc., from the MLS listing. The following variables were collected:

(1) location of the property (street address, town)
(2) final sales price of the property
(3) days of property on market
(4) lot size in square feet
(5) property taxes
(6) number of bedrooms
(7) number of bathrooms
(8) number of stories
(9) style of house (single family, twin, duplex, triplex, etc.)
(10) construction of house (frame, brick, stucco, etc.)
(11) existence of basement
(12) existence of garage
(13) type of heat
(14) age of house
(15) type of floors
(16) existence of fireplace
(17) existence of patio, porch, or deck
(18) existence of dining room
(19) existence of den, recreation, or family room
(20) existence of laundry/utility room
(21) type of plumbing
(22) existence of insulation
(23) type of walls
(24) quarter and year sold
(25) Census tract location

These data were hand transcribed from the Comparable Sales books for each quarter onto worksheets and then onto computer tape. The 1970 data was collected so that results from the early 1970's Lindenwold analysis on value capture could be tested using the newer, richer comparable sales data base. The 1980 data was collected to coincide with the license plate survey which had been done prior to this project. The fifteen years of data for Haddonfield was collected to provide a time series of data for a major station on the Line.

Each transaction was mapped into its appropriate Census Tract. For each Census Tract, the following information was collected from the 1970 or 1980 Census of Population:

(1) average age of resident
(2) number of black persons residing
(3) number of white persons residing
(4) total number of persons residing
(5) number of persons per family

(6) percentage of persons who are high school graduates
(7) number of people enrolled in college
(8) number of people enrolled in school
(9) number of people who use rail as their primary transportation mode for their journey to work
(10) number of people who use public transportation as their primary transportation mode for their journey to work
(11) total number of workers
(12) number of people who work in the Philadelphia CBD
(13) number of people who work in the City of Camden
(14) number of people who are managerial workers
(15) median household income
(16) mean household income
(17) per capita income
(18) percentage of families below the poverty level
(19) median value of owned home
(20) number of vacant housing units
(21) total number of housing units
(22) number of owner occupied homes

This information was then merged with the property transactions file.

Thus, in final form, the value capture model is tested by a data set which has transactions price as the dependent variable with characteristics of the property, demographic (Census) characteristics of the neighborhood, distance to the Philadelphia CBD (to account for the overall rent gradient effect), and transportation "full" cost savings as the result of the Line as independent variables.

II LITERATURE SEARCH

Many authors have discussed the theory of the impact of transit (or public facility) investment on property values. Some authors feel that a direct relationship exists, while others feel that the investment's impact on property values must be modified by some adjustment factors. Still others feel that no direct impact exists. These conclusions are related to the models used and the assumptions made.

Empirical tests of the impact of transit on property values are much more limited. Two basic model forms are a regression approach, which relates property values to transit access variables and other explanatory variables, and a simulation approach of the general equilibrium impacts of a transit investment on housing prices. Both the regression approach and the simulation method show limited value to be captured in the studies undertaken thus far.

Finally, the legal aspects of a value capture policy are explored.

The work of Spengler (1930) talked about the impact of transit investment on land values. However, the modern discussions of value capture started with Mohring (1961), Moses (1965), and Strotz (1966). The Mohring and Moses contributions are utilized in Sections III and IV.

Strotz assumes that all individuals have the same utility function which depends on land occupied in the north area and in the south area, a composite commodity, and a shift parameter.

Initially, all land is homogeneous and rents for the same amount. Then, a government program, which positively impacts only on northern land, is implemented. With free moving costs, the value of the land in the north is bid up while that in the south falls.

Maximizing utility subject to the individual's budget constraint of income equals outflow on rent of northern land and southern land and the composite commodity yields the typical first order conditions. Strotz then shows the response of an individual's utility to a public improvement in the north. Strotz ultimately concludes that the change in welfare from a government program can be measured by the change in rent (new north rent minus old rent [the same in both the north and south] times the amount of land in the north (assumed to be the same amount as in the south).

However, Strotz's approach entails many strong assumptions, e.g., equal land holdings by the individual in each area, requirements that individuals hold land in both areas, etc.

Lind (1973) also concludes that the benefits accrue to individuals and firms located on specific sites for a large class of public programs. This type of situation occurs whenever the economic advantages of a program serve to enhance the productivity and utility of specific locations.

If a public program increases the value of given locations to firms and households, the result of the program will be that the initial equilibrium in the market for land will be perturbed and a new equilibrium will be established. The new equilibrium will entail a new set of land rents and a new pattern of locations. The benefit from such a program, states Lind, is the sum, over all activities, of the changes in productivity associated with the move from the initial equilibrium to the new equilibrium. The rental value of a parcel of land is the net productivity of the activity located on that parcel and benefits are measured by the changes in these rents.

For small projects, Lind expects that land rents will only be impacted in the area affected by the project and so one only has to view changes in the value of these lands. However, for large projects, it is expected that land rents will change on the directly affected parcels and on other parcels as well, as activities play a type of musical chairs with the parcels.

Benefits in the larger case are the total of all changes in rents, positive and negative, multiplied by the respective quantities of land. Obviously, this presents serious practical difficulties in predicting the value of all rents with and without the project--since it is difficult to know all productivities of all activities in all locations, especially when the production of activity i at location j may depend on whether activity m or n is located at adjacent location k.

Lind concludes that changes in productivity for a large class of activities sum to zero and thus do not need to be considered in measuring benefits. In particular, Lind concludes that the benefits of a project can be approximated by measuring the total cost increase in profits of activities that locate on the land directly affected by the project. Where profits are eliminated, the change in productivity equals the change in land values and this change equals or is bounded above by the net change in the value of the land directly affected by the project.

Lind's model is an optimal assignment one where there are m parcels of land and n activities to be assigned to the parcels. The goal of the model is to maximize profits (rents, if the occupant is a consumer, and profits, if the occupant is a firm).

In summary, Lind's model was designed to be of use in evaluating the benefits of a large class of projects that affect specific parcels of land, but that are not so extreme as to alter the economic and spatial structure of the region. The results show that the relationship between the benefits of these projects and the changes in land values is not always a simple one, and that, in general, the change in the value of land does not equal the benefits, except in the case where all profits are eliminated. In this case, one need only consider the change in the value of land directly affected by the project. In the general case, the benefits can be measured or approximated by the increase in the profits of those activities alone which locate on such land. Overall, property rent differentials should yield an upper bound for estimates of the benefits of property enhancement.

However, Lind's model assumes that the market prices, other than those for land, don't change so that all benefits accrue to activities and/or landowners in the form of profits/rents. Such would likely be the case if land was not a large part of the production process. Likewise, as mentioned above, no locational interdependencies/externalities are allowed for. Zoning and other institutional impediments are not included.

Wheaton (1977) investigated the relationship of urban transportation investment and the benefits therefrom. He contends that the appropriate measure of user benefits is equivalent to a general equilibrium "income compensation" value for highway investment. The change in land rents and urban housing need not be separately considered if the forecast of highway user demand implicitly incorporates such changes. Urban commuting is viewed as a factor required for the consumption of housing and land. As long as the demand curve for the factor is a derived demand curve, its consumer surplus suffices as a measure of benefits and all other changes in final commodity markets (such as land) can be ignored Wheaton contends. But since the two markets are complementary, it can be argued, that the measurement can take place from either market, presumeably which measure depending on the ease of measurement and data availability.

Wheaton's model treats the price of travel as exogenous. Given this parameter, land use and commuting patterns evolve from a monocentric model of spatial equilibrium in which aggregate rental payments are included as part of consumer income. With this model, transportation investment reduces the price of travel, alters the pattern of land use and commuting, and changes income and rental payments. These, in turn, alter the pattern of land use and commuting, and change income and rental payments. This, in turn, alters the equilibrium level of welfare attained. The change in exogenous income necessary to compensate for this is precisely equal to the change in consumer surplus under the implicit aggregate travel demand function.

Wheaton's city has N identical consumers whose utility function has arguments of land and a composite commodity. All consumers have the same income. Rents are maximized subject to the utility function. In a general equilibrium context, the quantitity demanded of land must equal the quantity supplied at the equilibrium radius where the consumer's bid rent for land equals the opportunity cost of land.

Thus Wheaton concludes that all of the changes in the housing and land markets that accompany highway (or transit) investment can be completely ignored in benefit calculations if highway demand is adequately forecasted.

Pines and Weiss (1976) examine the extent to which the benefit of a project is reflected in the changes in land values as well as the relationship between the expected benefit and the existing structure of land values. The first is done to aid in an a posteriori evaluation of a land improvement project, while the latter is done to aid in an a priori evaluation of a land improvement project. The improvement occurs in a specific section of a closed city with given resources. They conclude that only if the changes in the relative prices of commodities other than housing are negligible do changes in land prices provide the necessary information. In the a priori case, cross section data on rent and quality differentials across the city can provide a precise estimate of the potential benefit of small quality changes.

In Pines and Weiss (unlike Strotz) land is only held in one region. Individuals have the same utility functions consisting of land, a composite commodity, and a parameter of locational quality. Community welfare is maximized subject to the constraints related to the exhaustion of land, the composite commodity, and the utility function.

Pines and Weiss' final result shows that the resident of the improvement area is impacted in the following way: his income is changed according to the change in the sum of land values in the impacted (dR_1/dS) and non impacted (dR_2/dS) areas modified by the real value of the marginal utility of the composite commodity U_{x_2}/TT and his costs of housing is changed in proportion (total population $\bar{m}$ divided by the population of region two m_2) times the real value of the marginal utility of the composite commodity times the decrease of land values in his location ($-dR_2/dS$). In equation form, this reads:

$$(1) \quad W = \frac{U_{x_2}}{TT}[\, dR_1/dS + dR_2/dS \,] - \frac{U_{x_2}}{TT} \frac{\bar{m}}{m_2} \frac{dR_2}{dS}$$

Thus the sum of the changes in land values (dR_1/dS_1) + (dR_2/dS_2) is misleading since it fails to account for the decrease in the costs of housing in location two. It is possible that total land value decreases but that the change in real consumption is positive, i.e., if $-(1/m_2)(dR_2/dS_2)$ is positive enough. This questions the results of Rothenberg (1965), i.e., (dR_1/dS_1) + (dR_2/dS_2). Likewise, the change in the value of land where the improvement takes place, (dR_1/dS_1), i.e., the Lind analysis, is also incorrect since it ignores the impact of the change in R_2. Strotz's analysis, i.e,

$[(dR_1/dS)-(m_1/m_2)(dR_2/dS)]$ ignores the correction factor.

Strotz assumes that $m_1=m_2$ so that he gets $(dR_1/dS) - (dR_2/dS)$.

The correction factor can disappear where the marginal rate of substitution between quality and housing is independent of the quantity of X consumed.

If the composite commodity is a normal good, then $dR_2/dS < 0$.

If the cross effect of a change in the price of land on the consumption of the composite commodity is zero, i.e., the elasticity of substitution between housing and goods is unity, then the total change in land values is zero, i.e., $(dR_1/dS) + (dR_2/dS) = 0$. If the cross elasticity of a change in the price of land is negative, then $(dR_1/dS) + (dR_2/dS) < 0$. It is also possible that $dR_1/dS < 0$. This says that an improvement in quality can be reflected in a reduction of land values all over the city.

Pines and Weiss conclude that the reliance on land values alone for the benefit measurement is at best a first approximation. In principle, one would like to measure the changes in real city income which are caused by the improvement. In practice, however, it seems impossible to separate the other causes for changes in real income.

Pines and Weiss derive criteria for the benefit based on current observations within a given city based on cross sectional analysis. The quality differentials are assumed to be measurable and empirically identifiable. If the determinants of environmental quality can be measured, then the cross sectional relationship between land values and quality differentials may be used to obtain an a priori evaluation of the project.

The above estimate reflects only the immediate increase in utility in the location where the improvement takes place, thus this estimate provides only a lower bound on the benefits since it fails to account for the additional increase in utility caused by the reallocation of resources. However, for small changes, no increase in utility results from such a reallocation. Therefore, they conclude that observable data can be used to obtain an unbiased estimate of the benefit.

Pines and Weiss (1982) criticize the approach of Wheaton (1977). They contend that Wheaton's conclusion of using the direct transportation demand rather than the indirect rent gradient only holds in specific cases (such as Wheaton's) which they regard as too simple. In cases where the projects yield benefits which are not directly priced in the market so that their value can only be estimated indirectly because they directly affect utility as well as user cost, then the rent gradient approach is indispensible. Commuting time would, in general, be such an example.

Many public projects produce outputs which are not directly marketable. Demand is revealed only indirectly through the rent gradient. Information on the rent gradient is the only feasible way for the ex ante evaluation of such projects. Thus for the limited purpose of evaluating projects to improve transportation--for which a market price exists--the rent gradient approach is required to capture the benefits not directly revealed in the market.

Lee and Averous (1973) investigate four models of the relationship of transportation and land use. They pose the question: under what conditions will land values increase the most near a particular point of access and less at greater distances from the point, e.g., a subway station. They then show the conditions for a rent value increase to be higher nearer a point of access. The rent gradient must be concave for this to hold.

Capozza (1972) has investigated the question of measuring the benefits of urban improvements, in particular the relationship between land values, property values, and the benefits of urban improvements. The relationship revolves about the nature of secondary benefits. Capozza studies this relationship by building three models, each more realistic than the last. He stresses, however, that all three models contain very strong assumptions.

His first model has property value changes as an accurate measure of the benefits of an urban transportation improvement (this model also requires the strongest assumptions). As the assumptions are relaxed, the next two models show that the true benefits of a transportation improvement are not fully represented by the direct or user benefits--nor, in general, is it correct to measure the benefits from the change in land values or housing prices.

The first model has a change in transportation cost equal to a change in housing rents and land rents. Therefore, using any one of these measures the full benefits of a transportation improvement. The fall in transportation and housing costs benefit the consumer but the offsetting fall in land rents is a loss to the land owners. If each of these is x, total benefits are x+x-x=x.

In this first model, consumer utility (with arguments housing quantity and a composite commodity) is maximized subject to a budget constraint. Demand for housing is perfectly price inelastic. The change in housing costs with distance from the CBD must be equal and opposite in sign to the transportation costs per unit distance in such a model.

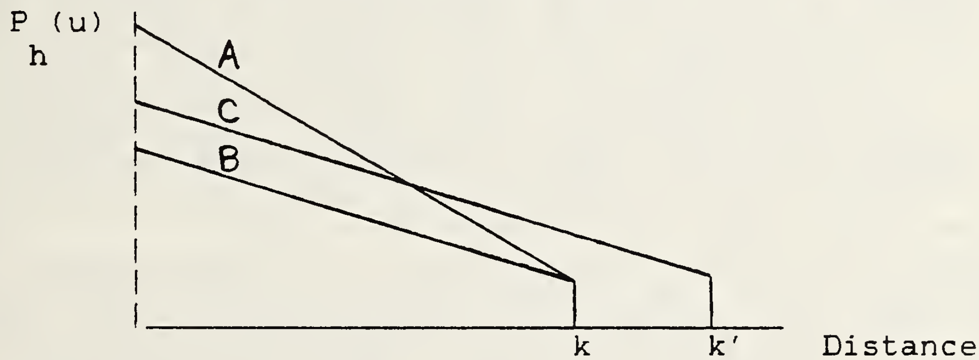
Housing production is specified as a fixed coefficient production function and the market is assumed to be competitive.

All three measures (transportation costs, housing costs, and land rents) are shown to be the same when aggregated over the whole city.

In the second model, Capozza allows for the substitution of land and capital in housing production (with a Cobb Douglas production function) but retains the perfectly inelastic demand for land assumption.

In this model, there are secondary benefits where the change in housing prices doesn't offset the change in land prices. If transport costs increase, housing prices will increase, but land prices must increase by a larger amount because as land prices rise, other factors (e.g., capital) will be substituted for land in housing production so that housing prices will rise less than the increase in land prices. If transport prices fall, land prices will fall more than the fall in housing costs.

It is also the case that the fall in housing prices will not be equal to the fall in transportation costs. If housing prices fell by the fall in transport costs as in the first model, curve B in the graph below would be the after improvement housing price curve while curve A is the before improvement housing price curve. But land prices would also fall. Because of the substitution, housing will be produced with more land per unit of housing than previously. Thus more land is needed to house the city's population and the city expands from k to k' and the new equilibrium housing price function will rise to curve C.



Consumers are still consuming a fixed amount of housing but it is more land intensive and less capital intensive.

Since the benefit measures some use is the fall from A to B, that measure is not correct since the change is from A to C.

Capozza's third model adds elasticity of demand in the housing market. The utility function is linear in the logs of housing and the composite commodity.

Consumers can now substitute housing for other goods as housing prices fall. Thus housing prices must fall faster than transport costs rise as distance increases. When housing prices fall, more housing is consumed per household. Thus using the before quantities of housing consumed underestimates the value of reduced housing costs while using the after quantities of housing consumed overestimates the value of reduced housing costs.

Capozza concludes that, in general, the change in property values is not an accurate measure of the benefits of an urban improvement. Nor are the user benefits, such as the reduction in transport costs, accurate measures of total benefits. Changes in land values and property values are not offsetting in a model in which substitution in the production function for housing is permitted. Only in the long run, if migration among cities is sufficiently elastic to prevent an increase in real income, can the benefits be measured indirectly by the increase in land values resulting from the migration. In any case short of equalizing migration, measurement of benefits must take into consideration not only changes in land values but also changes in property values, transport costs, and site characteristics.

Capozza followed the above work with another (1973) where he develops a general equilibrium model of a city with a land intensive highway system and a land economizing subway system. He then discusses the impact of subway construction on land values and uses. Subways will have a suburbanizing effect on the city and will influence both housing prices and land rents (but not equally). Capozza finds that when a subway station is added to a highway-only city, that land values and housing prices fall with the former falling more than the latter.

In Capozza's model, the interaction of the demand for land for housing and for transportation with the supply of land at each location will determine land rents.

The initial effect of a subway is to lower rents in the subway ring. But whether or not a hybrid city (one with subways and highways) is bigger or smaller than the comparable highway city depends on the relative magnitudes of a number of effects. Since the subway allows land in the inner ring to be transferred from road use to housing use, the city is smaller ceteris parabus. But the reduction in land rents causes producers to use more land which will make the city larger ceteris parabus.

Capozza calculates switching points where commuters will switch from highway to subway. Since switching costs increase commuter costs, they will increase land rents.

Capozza concludes that because of the relationship between transportation cost, on the one hand, and housing and land values on the other, any change in the transportation system will yield benefits not only to the commuter using the system, but also to land owners and housing consumers. Since housing values, transportation costs, and land values all effect the welfare of consumers or landowners, changes in any one of these should enter into a measurement of benefits.

Because substitution is allowed in the production of housing, the fall in land prices exceeds the fall in housing prices. Therefore, the methods of benefit measurement which only measures user savings, because the decline in housing prices is assumed to equal the fall in land values, are not correct since the latter two are not equal.

Capozza concludes that the short run and the long run (which allows for migration) effects are vastly different. In the short run, with inelastic labor supply, commuters benefit from lower housing and travel costs while land owners lose some rents. But in the long run, with an elastic labor supply, housing plus travel costs will return to their prior level. Commuters will no longer benefit from lower prices while land owners will benefit from the higher land prices.

Capozza concludes that:

long run benefits > user benefits > short run total benefits

In the short run, commuters receive most of the benefit, while in the long run, landowners reap all of the benefit.

Capozza (1973) simplifies the above analysis somewhat with another model. This model shows that reduced transportation costs don't fully reflect the benefits of the subway improvement. This is because the subway has significantly impacted the urban structure. The capital and land costs of providing housing and land values and housing values have changed.

A subway improvement in the short run will result in a fall in housing costs, land rents, and transportation costs. Net population density falls with the likely result that the land area of the city increases. In the long run, population, land area, goods output, and land values have increased while the sum of transport costs and housing costs have returned to the pre-improvement level.

In benefit-cost computations, the benefits are often portrayed to be the transportation cost savings for those who switch to the improvement as well as for those who stay with their existing mode. Secondary effects on housing prices and land values are ignored because they are believed to be offsetting, i.e., the gain to homeowners equals the loss to landowners.

But these effects are not offsetting. Because of the substitutability of factors in the production of housing, the changes in land values is larger than the change in housing prices. Thus the secondary effect must be accounted for. In addition, the long run effect of the increased incomes, i.e., the migration and resulting increased population, must be considered.

The relevant measure of net benefits is the change in the social cost of providing the necessary housing and transportation to the population. This social cost is the sum of the opportunity costs of the factors of production used in these activities. This yields the following formula:

(2) Δ SOCIAL COST = Δ TRANSPORT COSTS(=USER BENEFITS)

+[Δ HOUSING COSTS - Δ LAND

COSTS](=REORGANIZATION BENEFITS]

Thus the reorganization benefits must be accounted for. They exist because the reduced transport costs result in more capital and land being used in housing. In the absence of in-migration, the increased resource cost in housing will offset some of the benefits of the improved transportation system.

Fisch (1980) investigates the accuracy of changes in urban land values as a measure of the social benefits from public investments. When public investment has a geographical impact, it likely alters the spatial pattern of land use and land rents. For the improved area, the intensity of land use tends to increase as does the land rents. In the unimproved area, the reverse tends to occur as the result of the locational shift of demand. The overall net changes in land rents are often considered as a measure of the social benefits of the public investment.

In general, Fisch concludes that there is a lack of correspondence between the output indicators of public programs and that changes in land values generally are not an accurate measure (or approximation) of the benefits of such programs.

Goldberg (1970) investigates the relationship between transportation, land values, rents, and price elasticities of demand. Goldberg traces Haig's thesis that given a general transportation improvement, ceteris parabus, there would result a decline in aggregate land values. This is because while transportation overcomes the friction of distance, site rents plus transportation costs represent the social costs of the friction that remains. Thus, an improvement in transportation reduces the friction and hence reduces the aggregate sum of site rentals.

Goldberg's hypothesis becomes: a general improvement in transportation, ceteris parabus, results in a decline in economic rents in the aggregate. This need not, however, lead to a decline in real property and site rent in the aggregate.

If the supply of land with travel characteristic X is increased because of a transportation improvement, then housing costs and land rents can greatly change. As a result, prices, rents, and economic rents will fall if the elasticity of demand is perfectly inelastic. However, if demand is elastic, then lot sizes will increase and total expenditure on land also increases. So price or rent per unit will decline with a transportation improvement but aggregate rents or land values need not decline. Aggregate economic rent will, however, decline because of the increase in competition.

In Goldberg (1972), he concludes that improvements in transportation, and, therefore, accessibility are quickly capitalized into site rents.

Ferguson, Goldberg, and Mark (1984) have researched the impacts of the proposed Vancouver light rail system on property values. The study is an empirical one with no attempt to develop a theory of impact. The system will not be operational until 1986 and so the analysis is pre-impact. A control corridor analysis is used.

Their results show that the system's station locations are impacting on housing prices in 1983. The market pays higher prices for locations nearer to stations. The impact could not be detected prior to 1983 (the study data started in 1971). The line did not show any negative externality effects, e.g., noise.

The authors conclude that the market is reacting to the proposed system about two and one half years before operation. They conclude that this is a reaction to the increased certainty of the line's alignment and existence. As a result, future travel savings are being capitalized.

The empirical study is analogous to that undertaken herein. Real estate transactions price is the dependent variable and characteristics of the property are dependent variables along with variables related to the transit line in a regression analysis. The results show that property values decline $4.95/foot as distance from the station increases. The impact of the line seems to diminish at some point over 1,800 feet from the line and is nonexistent in a control area 2,400 feet away.

The results serve as a starting point in the complex issue of value capture by indicating that a premium is being paid for the increased access attributed to the stations. Theoretically, the fact that the stations are affecting property values provides evidence supporting a value capture policy. Practically speaking, the authors contend, the issue is far from clear. One of the major issues would be the identification of the area that would be subject to the extra tax. Those boundaries are difficult to determine. They suggest that the practicality and the costs and benefits of a value capture tax would have to be undertaken.

Dewees (1976) investigated the impact of the Bloor Street and Danforth Avenue subways in Toronto on residential property values. The technique was also a regression model like the one described above. He concludes that the average house at the end of the Bloor line and adjacent to the station would increase in value by $768 as opposed to a situation without the line. The rent surface perpendicular to the Bloor line became more steeply sloped. The impact of the line disappeared after seven minutes of "equivalent" travel time from the line.

Heenan (1968) also examined the Toronto experience but without a formal model and from the perspective of a real estate developer. He attributes a $10 billion investment explosion to the Yonge Street subway. Assessment increased 25% citywide, 45% in the CBD, and 107% in the transit area after the subway. However, none of this value is deterministically traced to the line.

Damm, Lerman, et al (1980) examine the impact of Washington Metro on property values. They investigate the capitalization hypothesis based on the anticipation of the implementation of the system not only on single family properties but also on multiple family and retail property. The study attempted to determine how different designs and implementation schedules might influence how much value is available for capture. The analysis only focussed on properties around the stations with the belief that the effects of transit will be highly localized around stations and a relatively small number of parcels may have reasonably large shifts in value. The remaining properties will be very large in number and are expected to have a virtually infinitesimal decrease in value. They conclude that attempting to measure these small decreases is likely to be a fruitless exercise unless an enormous and prohibitively expensive sample of real estate transactions is collected.

A Box-Cox transformation was utilized so that the appropriateness of alternative functional forms could be tested. As above, the dependent variable is real estate transaction price while the independent variables are transit related, demographic, and site specific. The best price equation was the regression equation plus one with the whole result squared.

The study has provided some tentative empirical support for the thesis that real estate property shifts do indeed occur in areas near transit stations. But it also leaves open other questions about the economic efficiency and equity associated with alternative value capture policies. The authors suggest that retail sites may be the best suited for value capture.

Wabe (1971) also estimates housing prices as a function of transportation access variables as well as property description variables. A one penny decrease in transport price would raise housing prices by 18.74 pounds while a one minute decrease in travel time was worth 20.38 pounds in terms of the price of a house.

Anas (1979) develops market clearing property values designed to bring travel and location demand into equilibrium with housing supply. This is all done in the context of a rapid transit system which changes travel time and travel cost relative to the competition--an auto mode. His analysis of probabalistic travel demand, probabalistic housing demand and supply of land sheds light on the extent to which property values will increase due to the installation of a rail rapid transit system.

A simulation with made up data is run. Anas' results show lower rents in the centralmost areas after the transit investment. In the suburban zones, the rents are increased throughout to reflect the cost savings impact of transit. The aggregate change in property values can be positive or negative when the whole city is considered. This level of rent changes depends on the vacancy levels. If vacancies are between 0-1%, rents increase significantly with transit. But with vacancies in the 2-3% range, no change in rents occur. After 4% vacancies, rents decrease significantly.

The value capture scheme by Anas taxes the excess value of properties, compensates for all properties which have fallen in value, and uses the remainder (if any) as a payment toward the capital cost of the system. Under optimistic assumptions, 26.8% of the capital costs of the system can be paid via value capture while under pessimistic assumptions, only 8.8% of the cost can be so paid (for the 0% vacancy case). Thus Anas concludes that his overall results are likely to be optimistic. He regards the claims of others that 20-40% of a system's capital cost can be covered by value capture to be much too optimistic. One reason for his conclusion is that his model assumes that all employment is downtown whereas only 30% is actually downtown in many cities.

Anas (1980) continues exploring the application of discrete multinomial choice models of housing and travel demand via market simulation. This simulation is then used in an urban transportation corridor with a multi-nucleated employment distribution. In this paper, Anas concludes that only a small portion of the cost of a rail transit system can be raised by value capture.

Eight different transportation policies are simulated: (1) free transit, (2) fast rail transit, (3) short length of line rail transit, (4) stations spaced closely, (5) stations widely spaced, (6) doubling of gas prices, (7) doubling CBD parking rates, and (8) only local street highway access. These eight cases are compared to a base case.

Anas notes that although the rent gradient and aggregate property values in the corridor are very sensitive to transportation policies, the distribution and mobility of households and the level of transit ridership are extremely robust and very difficult to influence in the short run via transportation policies. Under the policies discussed in this section, transit investment disturbs property values from +.024% to only +1.007% of their level in the absence of transit.

He also investigates 10 different employment policies and six different housing policies. These influence aggregate property values between -.54% to +1.03% above the base. Obviously, the best case is when employment is centralized.

Transit investment has a stronger impact when it is associated with stringent controls which increase the cost of auto transportation. Even under the most favorable conditions to transit, changes in transit investment only increase metropolitan property values by 1%. If this increment is fully captured by a property taxation policy, then over 50 years, it's present value would pay for 14% of a half billion dollar transit investment. This is the best possible capture rate. Under most other scenarios considered, the return is 3.8% or less.

Anas and Lee (1980) use the above type of model to investigate the potential for value capture via simulation in Chicago. They conclude that about 6% of the capital costs of rail transit projects can be recaptured under 1970 conditions assuming efficient and fair tax assessment procedures and a certain amount of care in the selection of rail transit alternatives. The authors note that their assumptions are conservative and that, therefore, the actual value capture potential may be substantially higher. Some of these assumptions are that commercial properties and non-work trips are not in the analysis. No one employed outside of the CBD was assumed to use transit. It was also assumed that no relocation of households to the new study area would occur. Positive government development projects could increase the rent potential.

Knight and Trygg (1977) summarize the land use impacts of rapid transit systems. It is felt that a rapid transit system will stimulate, revitalize, reorder, compact, and/or create infrastructure economies in urban development in comparison to what would have occurred without the transit investment.

However, many questions have been left unanswered by the studies to date:

(1) Will a system truely transfer wealth and/or population from other areas
(2) Do different technologies have different land use impacts
(3) What are the differential impacts of policy settings
(4) What are the differential impacts of physical settings
(5) Can a region's development be focussed or its average density increased by transit
(6) Will the transit investment strengthen the CBD or the suburbs
(7) What is the timing of the impacts

The authors cast doubt on the ability of a transit system to improve access significantly as in the early transportation land use models. This is because modern urban transit systems rarely, if ever, provide a major effective increase in accessibility, because the areas served tend to be better served by auto . The authors thus feel that major land use changes around transit stations today also require the concerted actions of other powerful forces in addition to transit induced accessibility increases. Thus transit is but one of a series of factors which leads to development. These factors include: (1) local government land use policies, (2) regional development trends and forces, (3) availability of developable land, and (4) physical characteristics of the area.

Toronto, BART, METRO, Chicago, Cleveland, and Lindenwold are included in the literature search.

The authors conclude that transit is an important but not sufficient condition for such development. The transit system can become the focus or catalyst around which the suggested policies are implemented, which, in turn, affect development in the area. They feel that transit can focus growth but probably does not generate or create new regional growth. If the growth would have occurred elsewhere or later, it may occur at or near the transit station or sooner because of transit.

The availability of land for development and other market forces may be the most important influence on development discussed thus far. If no developable land is available, a transit system will have difficulty influencing development, e.g., a median strip transit line.

The authors' literature search found very little documentation of the geographical extent of transit related impacts (save the Lindenwold studies).

Knight and Trygg conclude that transit alone seems no longer enough to insure such development, in this day of very high accessibility often only marginally improved by the transit system. If development is to be created, other factors such as those cited here must be effectively brought into play at the start of the transit planning process. This calls for a more coordinated land use/transit planning process than has often been evident in the past.

Claims of massive net increases in property tax revenue because of a transit improvement seem hard to justify. The general effect is a focussing of development. Transit can be a catalyst in the local government development process. It can provide the rationale needed to gain support for land development controls as well as incentives to focus growth. Rapid transit will not automatically revitalize and reshape our cities, but it can do much--if we can learn to understand that role and the others which must accompany it.

Hagman and Misczynski (1978) discuss the question: could special assessment finance a subway (pp. 319-335)? Initially, a theoretical question is asked: should the value captured be limited by the cost of the project or should the total value be captured? Miscyznski concludes that this is not a revelvant question for this case since it is likely that costs would justify recapture far in excess of land value benefits to adjacent landowners. This judgment is substantiated in empirical work by Boyce, Allen, et al (1972), Anas (1979, 1980), Damm et al

(1980), etc.

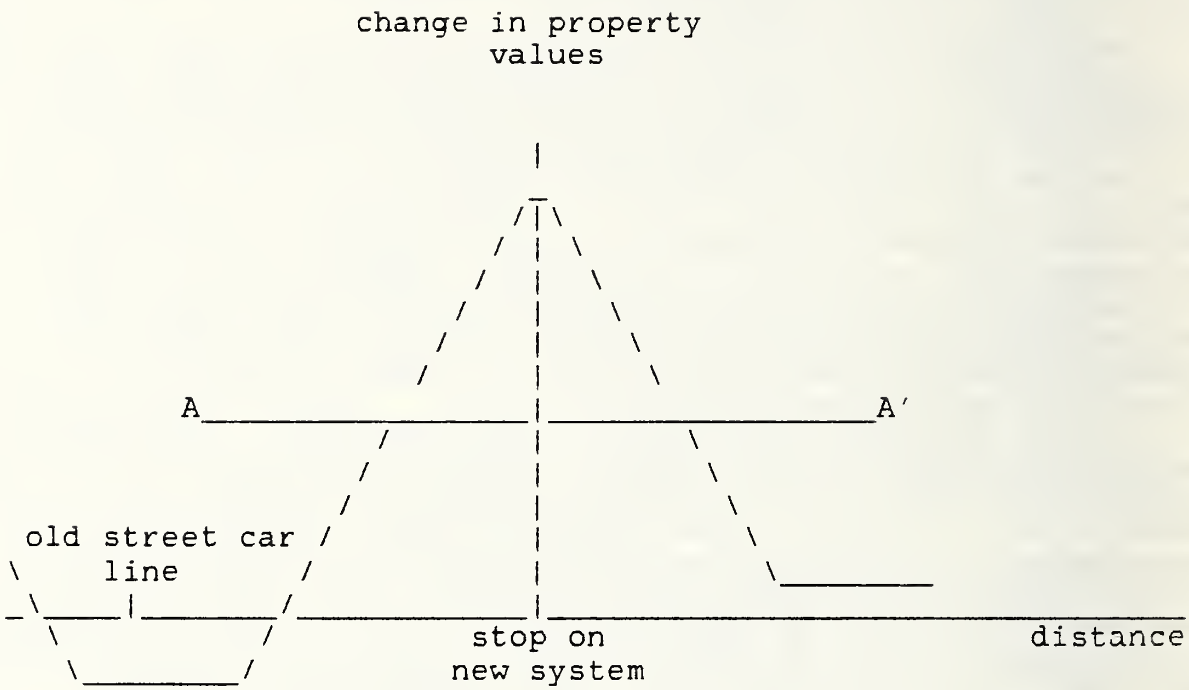
Misczynski believes that the benefits principal should be followed and that the tax should be in proportion (if not one to one) to the benefits received.

Misczynski also follows the general equilibrium approach. He expects complex distributions of benefits and harm from such transportation improvements. These include increased property values near the system but also some decreased values near the system due to externalities (noise, pollution, etc.). Some far away plots may lose value due to a decline in relative locational advantage. He expects location specific benefits to result in increased land values for fortuitously located parcels, that is, the benefits are capitalized into land value. He states that the law recognizes that change in market value of real estate is a common conceptual basis for identifying special benefits, i.e., those that are site specific.

It is important to distinguish between special and general benefits from public improvements. General are those that are so diffused that they can't be easily ascribed to particular parcels, while special benefits are those on parcels near the improvement. In general, the law holds that only special benefits can be specially assessed. The courts have also held that special assessments can only be made on public projects which are local in character. If the projects are non local, then the courts have held that the benefits are non local and hence that special assessments can't be used. Major transit systems could fall into this non-local category.

As a first approximation, it seems useful to identify special benefits with location specific benefits and, hence, with benefits which result in increases in land value. Courts in many states seem to have agreed with this, and change in market value of real estate is a common conceptual basis for identifying special benefits.

However, the situation is still complex. Suppose that a transit stop has the following spatial distribution of benefits:



The courts have often determined that in deciding whether property is subject to assesssment, as being specially benefitted by an improvement, that only the benefits derived by it in excess of those derived by the property throughout the municipality generally can be considered. Misczynski states that the courts would have to do some "line drawing", with everything above AA' counted as special benefits.

Special benefits are thus relatively large increases in property values caused by and usually near a public investment. If this is an acceptable theory of special benefit, then there need be no problem showing that such benefits arise from mass transit systems, major highways, and other "non-local" improvements. There is considerable evidence that property values at strategic points along such projects often rise differentially in limited areas. It follows that such benefits could be specially assessed.

An established part of the special assessment tradition is that if project costs are to be distributed in proportion to benefits, then the public, through general tax revenues, should pay the portion of project costs that general benefits are to total benefits.

However, even if special benefits exist, certain other criteria must be met before an assessment is allowable. These are: the project must have a public purpose and general constitutional and common law standards must be met. These would seem to be met in a transit case.

A major difficulty is benefit measurement. This problem is especially acute for special assessments, as opposed to other benefit recapture schemes, because of the tradition that the amount of assessment against each parcel be determined before the project is constructed. This is because it is felt that propertyholders should know their assessment beforehand so that they can determine if the benefits are worth the "price". Presumeably, however, a project wouldn't be built unless benefits exceeded costs (although not necessarily to this particular group--but compensation is theoretically possible). In addition, if nothing more than the special benefits are to be taxed away and they are only a portion of the inflation adjusted increased property values, no taking can take place and the increased property values reflect those benefits. If the tax takes place regardless of whether the property values increase, then the landowners are correct. But if the tax is on the percent above AA' and only is assessed if values increase above AA', then there should be no concern. Of course, the planners have a problem should the property values not increase--since the project can't then be financed.

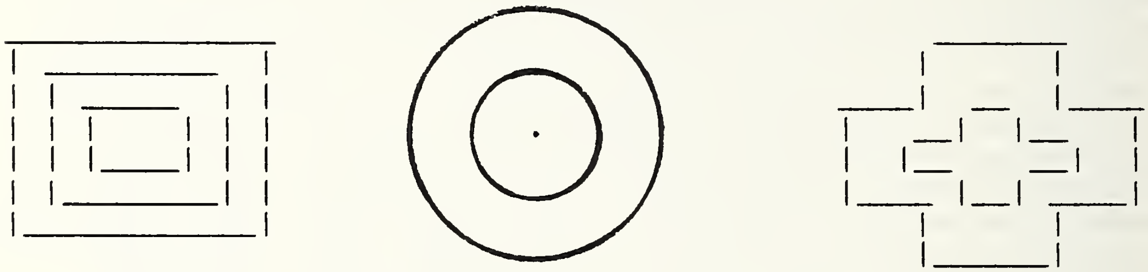
Presumeably, if one could wait until property values increased and then make the assessment rate, the estimate of assessment per household would be more exact. A problem still exists concerning the attribution of all of the increases to the improvement in question.

However, the prior attribution and measurement problems have not emasculated the concept of special assessment. This is because the courts have accepted "tried and true" front footage, lot area, etc., measures. Misczynski feels that ad valorem land and property taxation within a designated benefit district may have many of the same "tried and true" virtues. Secondly, the courts have always allowed some lack of preciseness in special assessment taxes. This lack of accuracy accepted by the courts makes life easier for the proposers of the tax but may also make them lazy and also may subject some propertyholders to too high or too low taxes.

A benefit district must be established as well as a method to apportion assessments to each parcel within the district in proportion to the level of special benefit received by the parcel. As mentioned above, frontage and lot size have been popular methods to allocate assessments and define districts. The ad valorem method (which puts a tax on the value of the property) is easy to administer as are the previous two types.

A question arises whether to tax the land or the land plus improvements. Both the California law and the Massachusetts' bill authorizing special assessments for rapid transit systems established land only as the assessment base. Some special assessment districts (not for transit) allow both, but most apply to land only. This can create difficulties in developed areas where no vacant land transactions occur and so the value of the land must be estimated from total transactions prices. Land only taxes also stimulate intensive development.

The conventional wisdom seems to be that ad valorem benefit districts for a transit system should center on the stations. As is shown in Section III, this is too simple a concept. The California law and the Massachusetts bill, however, are so patterned. The California law called for a uniform tax rate within the zone while the Massachusetts bill recognized differential rates for different parts of the zone. Misczynski portrays such zones as concentric squares, circles, and crosses around transit stations, i.e.,



Drawing precise boundary lines would likely be quite subjective and apt to generate some political controversy. There is little objective guidance: almost nothing is known about the precise way property value increases are spatially distributed around stations. There does not seem to be any significant empirical work on the subject according to Misczynski. This is not correct as is demonstrated herein.

Misczynski suggests using an ad valorem tax, based on the change in property values. This is in line with the proposals to be made herein. One has to be careful here to specify a date from which the increases will be measured. This is difficult because of anticipatory effects. In addition, other events, e.g., inflation, general improvements, etc, may cause land values to increase. These could be mitigated if one had a good property tax assessment system. Bad assessments can create major burdens when the tax is on land value changes. This is because the tax rate is likely higher for the special assessment and because of the base of the change. Suppose a property tax of 3% of value exists on a house worth $100,000. This would be a $3,000 tax. If the house in underassessed by 10%, the tax will be $2,700, a 10% change. If an improvement occurs and the real value of the house goes to $120,000 (a $3,600 tax) but the assessor overestimates the value at $132,000, the tax will be $3,960 or 10% more than it should be. However, a value change tax on such a house at 30% should be $120,000 - $100,000= $20,000 x .3 = $6,000 but will be $132,000 - $90,000 = $42,000 x .3 = $12,600 or 110% more than it should be. So assessment errors can have great effects in a value change tax.

Although there are anticipatory changes in land values, it may also be the case that some changes in land value don't occur until after the project is fully developed and in service. However, if funds are required for construction, this creates a timing problem. This can be handled by issuing revenue anticipation bonds.

There are some interesting issues when the improvement passes through multiple political jurisdictions. Should each jurisdiction specially assess? Should this hold even if the jurisdiction made no financial contribution? Is such an arrangement administratively efficient? Would it be socially equitable if one town wanted development and hence assessed at low rates while another town abhored development and assessed at high rates? On the other hand, what of the rights of communities to decide their own development destinies? California allows regional transit districts to do the assessing as the efficient level.

Local destiny can be controlled somewhat. Most special assessment statutes require abandonment of the project if a majority of property owners in the benefit district petition that the project be stopped. California law on special assessment for rapid transit requires an election and a 2/3's majority in favor of the project. On the other hand, since the landowners are not the total beneficiaries of the project, one might argue that they should not have unilateral ability to control the project and to prevent their own assessment. Under such a theory, those not desiring to contribute to defense expenditures could withhold a portion of their Federal income tax. A free rider effect is also at play here. If the transit system is built despite the voting down of the special district, then the property owners gain the benefits without incurring the costs. The Massachusetts bill does not allow the local owners the right of refusal, presumably because of these reasons.

There is an interesting income tax repercussion with respect to special assessment taxes. They are not deductible for personal income tax purposes. Rather, the assessments are put into property value for tax purposes and thus one does not have to pay capital gains on the increase in the value of the land up to the amount of the assessment paid. Of course, if one does not sell one's house or if one merely buys another house, this capital gains "saving" is worthless.

Misczynski feels that special assessments are appropriate for use for transit financing. The legal problems to be faced in using such a tax are not large. Rather, any problems are likely to be political. Since such taxes would distribute the costs of public projects differently than is currently the case, a de facto income redistribution would occur and hence those who gain will tend to support the proposal while those who lose will do otherwise. Misczynski concludes that the method (value capture) seems to be a remarkedly equitable way to finance a number of kinds of major public projects.

III THEORY OF MODAL CHOICE, STATION CHOICE, AND SAVINGS AND EMPIRICAL TESTS OF STATION CHOICE

Value capture is the concept of the beneficiaries of an investment, service, or act (read event) paying all or a portion of their benefits to the provider of such an investment, service, or act in order to pay for the costs of providing some or all of the event. If the value of the benefits exceeds the costs, most versions of applied value capture would only attempt to partially capture the benefits to cover the costs. If the level of benefits were exceeded by the costs, applied value capture might attempt to capture some or all of the benefits depending upon other policy goals.

Viewed in the above fashion, all user charges would be construed as a means of value capture and all consumer surpluses would be seen as value which could be captured.

In many markets, however, benefits may accrue to non-users and/or may manifest themselves in markets away from the event market.

In the case at hand, consider an investment by a governmental entity in a transit system. Such a system will create benefits for the users of such a system (reflected by the price they pay and their consumer surplus). In addition, individuals who continue to drive on the road system competing with the new transit system will benefit too by the extent of the reduced congestion caused by some motorists diverting their trips to transit (reflected by the gain in consumer surplus to such individuals as measured by the lower "full" price of driving). Non-users will also benefit as the result of lower pollution levels as well as other positive externalities.

However, many of these benefits are difficult to measure because the demand curves per se are hard to measure and because some goods do not transact in a distinct market, e.g., pollution does not have its own market, and time cost valuation has proven to be somewhat elusive when figuring out the "full" price of driving.

The research herein investigates whether the benefits to the consumer of the event (in this case a transit service) and to the non-consumer (other drivers in the area, the beneficiaries of lower pollution, etc.) are all recorded in yet another market--the market for real estate in the area surrounding the transit investment.

If the real estate market is shown to capture the value of the transit investment, then strategies and policies to recapture some or all of the benefits of the transit investment can be initiated. These strategies include:

(1). taxing the benefits via a piggyback on the local property tax.
(2). taxing the benefits in a lump sum when the property changes hands.
(3). instituting a special tax on land only.
(4). establishing a special assessments district.
(5). taxing only a percentage of the benefits.

Such research is not new, however, and the modern era of value capture theory can be traced back to Mohring (1962), Moses (1965), and Strotz (1966). Many other contributions have been subsequently made as shown above in Chapter II.

It is first necessary to delineate an area of impact for the transit investment. This area is defined as the area where individuals would choose to utilize the transit system over their previous alternative-the automobile.

The model assumes that individuals are located throughout a circular city. Work takes place only within the Central Business District (CBD) while residences surround the CBD city. With no distinguishing characteristics associated with the landscape and with individuals of identical tastes and incomes, the city would develop as a perfect circle. These are the typical Von Thunen assumptions. Of course, the above assumptions would never be met, but they provide a starting point for the value capture analysis.

The model assumes that an individual's workplace and homeplace are specified and that an individual commutes one roundtrip per day. Since the consumption of work, housing, and quantity of work trips are fixed, the individual will maximize utility by minimizing his/her roundtrip transportation cost. Transportation cost is defined here to represent a "full" cost, i.e., fare plus time costs plus other non-monetary costs.

A straight line transit line is constructed running from a suburban station G to the Central Business District (CBD) H. Driving can occur on a straight line basis as per Von Thunen (road networks can be explicitly considered).

The full theoretical model is developed in Appendix A. A simplified example is shown below utilizing the following notation:

F = fare on the Line ($)
P = CBD parking costs ($)
c = auto cost per mile ($/mile)
D_{iX} = straight line distance from location X to location i, i = G,H (miles)

TC_j = total cost of using mode j, j = A (auto), T (transit) ($)

The full theoretical model uses wait time for both modes, line haul time for both modes, the value of time for users, other non distance related automobile costs, egress cost and time in the CBD for both modes, and the value of modal amenities.

The cost of a round trip from location X to the CBD by auto, i.e., $TC_A = 2cD_{HX} + 2P$, is equated to the cost of a round trip from X to the CBD by transit, i.e., $TC_T = 2cD_{GX} + 2F$, to yield the locii of all points X where an individual will be indifferent between using the automobile and using transit, i.e., $D_{HX} - D_{GX} = [(F - P)/c] = K$, where

K is a constant given that F, P, and c are known. The form of $D_{HX} - D_{GX}$ is that of a hyperbola which bends around G if K is positive and around H if K is negative. The larger K becomes, the closer the hyperbola is to G and the "tighter" it bends around G. All individuals residing to the right of the indifference locus will find that transit is cheaper than auto, while the reverse will be true for all individuals residing to the left of the market boundary. This is the modal split model and is shown in Figure 1.

As shown in Appendix A, the model can become much more complicated. More transit stations can be added, the above mentioned variables can be added, and the assumptions used to derive the above model can be changed, e.g., a road network can replace straight line travel, different values of time can exist, congestion can increase travel times and costs near the CBD, etc.

The station choice model is also complex as is shown in Appendix A. A simplified version would use the following notation for station G and a more distant station I:

F_i = fare from station i, i = G,I ($)

D_{iX} = distance from location X to station i (miles)

c = auto cost per mile ($/mile)

TC_i = total cost of using station i ($)

All of the transit variables which could augment the modal choice model could also augment the station choice model.

The round trip cost of using using station i for a transit trip from X to the CBD is $2cD_{iX} + 2F_i$. Equating the cost formula for each station and solving for the locii of all points X where users would be indifferent as to which station they used yields, $D_{GX} - D_{IX} = [(F_I - F_G)/c] = \hat{K}$. All persons residing to the right of such an indifference locus would find station I cheapest while those residing to the left would find station G cheapest. The station choice hyperbola would look like the mode choice hyperbola in Figure 1.

The values of K and $\hat{K}$ are sensitive to the values of the parameters which determine them. Since these variables are controllable by a public entity either directly, e.g., the fares, or indirectly, e.g., via a parking tax or a tax on auto use, social

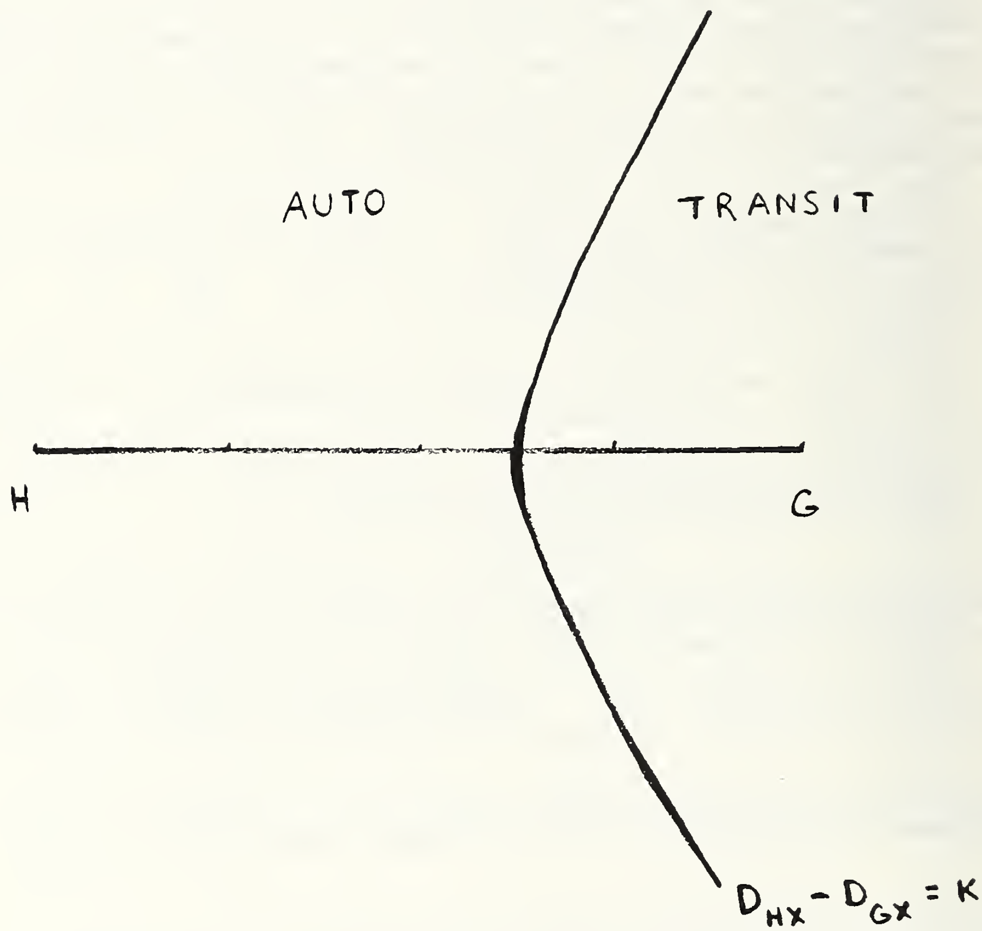


FIGURE 1 : SIMPLE AUTO/ TRANSIT MARKET
AREAS (MODAL SPLIT)

planners could change K ($\hat{K}$) by changing the control variables.

A third model is derived from the same basic form as the station choice and modal choice models. This model is the savings model and is found by subtracting speed line cost from auto cost, i.e., $TC_A - TC_T = S$, where S = savings. The above can be rewritten as $D_{HX} - D_{GX} = K + (S/2c) = \tilde{K}$ in the one suburban station notation. If S = 0, then the modal split model is found. Hyperbolas exist for various levels of savings as is shown in Figure 2.

The equal savings locus (one for each level of savings) enables the beneficiaries of transit to be spatially located by their level of travel cost savings enjoyed. This savings accrues to every location (property) in the transit capture area (the area to the right of the modal split market boundary) at the level specified in the equation above. While (in the real world) not every occupant of property at X avails themselves of the savings by using the transit system (some may drive because of their misperceptions of the variables in the model, some may have different parameters than those specified in the model, some may not be able to use the system [handicapped], some may make their decisions based on variables not included in the model, some may not work in the area served by the transit system, some may need their car in their work, etc.), each location in the capture area has the potential of saving S to some potential user. Hence, each piece of land has an opportunity value of S in savings whether it is realized by the current occupant of the property or not.

The Lindenwold Line analysis involves the Philadelphia CBD and seven suburban park and ride stations. A modal split locus exists between each of the seven stations and the Philadelphia CBD, i.e., seven K's like the one above exist. In addition, 21 station choice locii exist for each of the 21 binary station choices possible, i.e., 21 $\hat{K}$'s like the one above exist. Despite the existence of 28 equations required to calculate these 28 K's and $\hat{K}$'s, only seven of the 28 equations are independent. Since the savings locii, $\hat{K}$, are made up of the K's and the S's and the K's can not be empirically estimated (because of a lack of modal split information), it was hoped that the K's could be determined by utilizing the $\hat{K}$'s. Unfortunately, although the differences in two K's can be estimated, the lack of independent equations makes it impossible to estimate the individual K's. Since the K's are needed to calculate the savings $\tilde{K}$'s, an alternative method

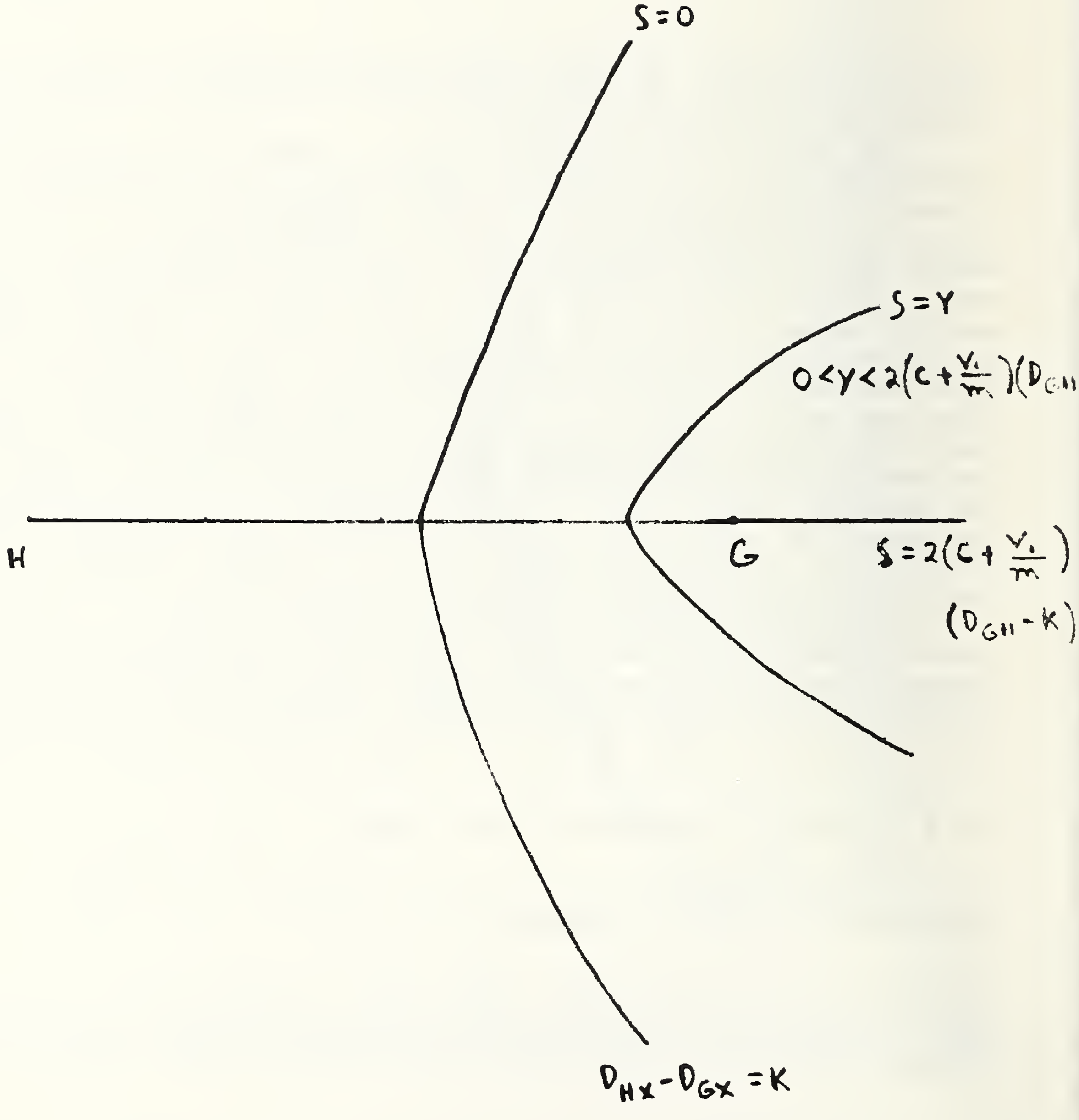


FIGURE 2 : SIMPLE EQUAL SAVINGS LOCII

of calculating savings levels by spatial location had to be determined.

In order to solve this problem, auto variables to the CBD will be chosen to be "reasonable" values. These values, used in the equation for $D_{HX} - D_{GX}$ will yield a K. Although this K is not empirically testable, it will be used herein with its value changing as alternative "reasonable" values are chosen. This is no different than what would be done in a sensitivity analysis except that those values which yield the empirically correct K_{Pi} are not known. As mentioned above, it is the intent to show the empirically correct K_{ji} in the analysis herein.

Thus, alternative "reasonable" savings levels will be calculated for each location to be used in the empirical testing of the savings capitalization hypothesis.

Although the modal choice model could not be empirically tested, an auto cost equation was developed, i.e., $TC_A = 2cD_{PX} + 2(V_{1A}/m)D_{PX} + 2B + P$.

The c was chosen to be the auto cost per mile as used by the local MPO (Metropolitan Planning Organization)--the DVRPC (Delaware Valley Regional Planning Commission). This is an out of pocket cost of 7.87 cents per mile.

The D_{PX} was chosen to be the distance from the centroid of the Census Tract to the corner of Broad and Market (the center of the Philadelphia CBD) via either the Walt Whitman or the Ben Franklin Bridges (whichever yields the minimum distance).

The m was chosen to be the miles per hour as used by the local MPO. This ranged from 20 to 30 miles per hour with a mean and a mode of approximately 23-24 miles per hour. An unweighted average of 23.5 MPH was used.

The value of time V_{1A} was unable to be estimated from the station choice data because the multinomial logit model available would not run with the data set. The data set utilized DVRPC time and cost estimates from Census Tract centroids to each of the seven park and ride stations. From the data shown in Appendix B, station choice probabilities as a function of various decision variables, e.g., access time and cost, could be estimated. However, the error message from the model indicated that multicollinearity between the time and cost variables would not allow the model to be estimated and hence a revealed value of time could not be calculated.

The fallback position was to utilize a value of time calculated on the basis of some journey to work analysis by McFadden, Talvitie, and associates (1977) which gave values of time as a percentage of the wage rate for in-vehicle auto time (178% of the wage rate), in-vehicle transit time (74% of the wage rate), transit expected wait time (165% of the wage rate), and transit access/egress walk time (338% of the wage rate).

Since the wage rate was not available for each Census Tract, the mean family income for each Census Tract was divided by 2,080 hours to yield an hourly income rate. It was assumed that a commuter from the Census Tract would use such a figure as the basis on which to value his/her time. The figure was then multiplied by 1.78 to give an estimate of V_{1A} for each Census Tract. Such an estimate overstates the wage rate of the user since multiple family members may contribute to family income and wage/salary income is only a fraction of family income, e.g., other income comes from rents received, interest, dividends, etc. However, since no estimates of the number of workers per household and their contribution or wage as a percentage of total income are available, the above calculated numbers are used. The result is to overstate the value of time in the analysis and to relatively understate out of pocket dollar costs. An implicit assumption is that McFadden et. al.'s results are transferable over space and time.

The B was chosen to be the cost of obtaining a commuter sticker for crossing either the Ben Franklin or Walt Whitman Bridges. This costs $6 (in 1980) for a monthly sticker plus a payment of $.25 for each crossing. Assuming a 22 day work month, the average auto commuter would have 44 bridge crossings in a work month. This would cost $.25 + ($6/44) = $.3864 per crossing.

The P was determined in the following fashion. No formal records were found of Center City Philadelphia parking costs. An established parking operator was contacted and he stated that the commuter parking rate for the CBD monthly parking in 1980 varied between $90 and $150 depending on quality (enclosed, lot, etc.) and location. The simple average ($120) was taken and divided by 22 work days to yield a daily CBD parking cost of $5.45.

Thus the cost of driving from each Census Tract centroid X to the Philadelphia CBD was estimated as:

$$TC_A = \$6.2272 + \$.1574\, D_{PX} + \$(.0851063)\, V_{1A}\, D_{PX}$$

The cost of using any one of the seven stations is more complicated. It is a function of the round trip driving cost to the station from the trip origin, the round trip value of time of such a drive, the round trip fare on the Line, the cost of parking at the station, the value of the round trip time on the Line, the round trip value of the time spent waiting for the train at the station, and the round trip value of the time spent walking from and to one's car and the station in the parking lot.

The fare is the applicable fare for each station for 1980 (See Table 2). The station parking cost is calculated by multiplying the pay parking spaces used times a quarter (the pay lot rate) divided by the total used spaces (both pay and free).

The results of this calculation are shown in Table 2.

The time on the Line from each station to the Philadelphia CBD is taken from the Line's timetable. The waiting time for the train at each station is found by dividing the rush-hour schedule headway in half. The walking time from the parking lot to the station is calculated by taking the distance from each parking lot centroid at a given station, weighting them with respect to cars using the lot, and calculating the average distance walked by a park and ride patron at the station. This was then converted to minutes by assuming a walk speed of 2.5 MPH. These results are shown in Table 2.

TABLE 2 BASIC DATA FOR STATION COSTS

	One Way Fare	Average Station Parking Cost	Line Haul Time	Wait Time	Walk Time to Station
FERRY AVE	.75	.1250	12	2	1.95
COLLINGSWOOD	.95	.1960	14	2	1.27
WESTMONT	.95	.1698	16	2	1.40
HADDONFIELD	.95	.1939	18	2	1.42
WOODCREST	1.15	.2500	21	2	1.41
ASHLAND	1.15	.1472	22	2	1.53
LINDENWOLD	1.15	.1464	24	2	2.52

Converting the times from minutes to hours, the McFadden et. al. study cited above also gave values of time for transit users. The value of time was then calculated in the same fashion as with the auto users where it was assumed that transit users value their in-vehicle auto access time at 178% of their hourly income rate, in-vehicle transit time at 74%, transit expected wait time at 165%, and walk time from the parking lot at 338%.

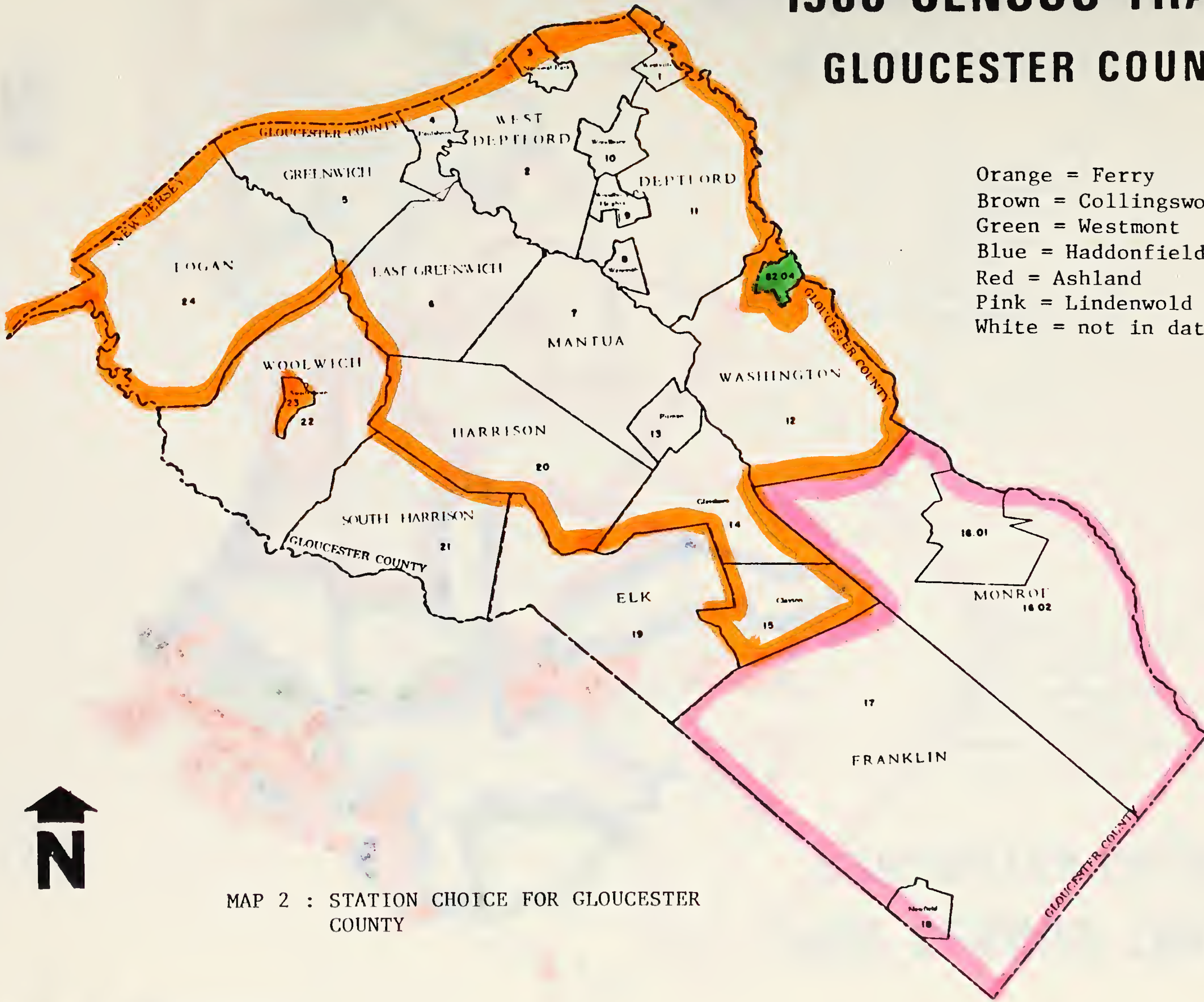
The travel time and cost from each Census Tract centroid to each of the seven park and ride stations were calculated by the DVRPC from their regional highway network model.

The preferred station for each Census Tract is the mode station actually chosen by the users from each Census Tract. This information is shown in Appendix B. (Appendix B also contains non-duplicative license plate data from a December, 1979 Lindenwold survey undertaken by the authors. Thus Appendix B is not comparable with Table 1). Given that preferred station, the Census Tract's transit costs are calculated using the parameters and variables above. Savings for each Census Tract are then calculated by subtracting the transit costs from the centroid of said tract to the tract's preferred Speed Line station from the auto costs from the centroid of the Census Tract to the CBD via the minimum distance bridge. This savings variable is then used in the value capture analysis. This is shown theoretically in Section IV and empirically in Section V. The reader interested in only the empirical results can pass directly to Section V.

As shown in Maps 2, 3, and 4, the station market areas tend to show the band effect of Figure 1 and of Figure 7 of Appendix A. Maps 5, 6, and 7 show the level of savings spatially. They too follow a banded effect as in Figure 2.

1980 CENSUS TRACTS
GLOUCESTER COUNTY

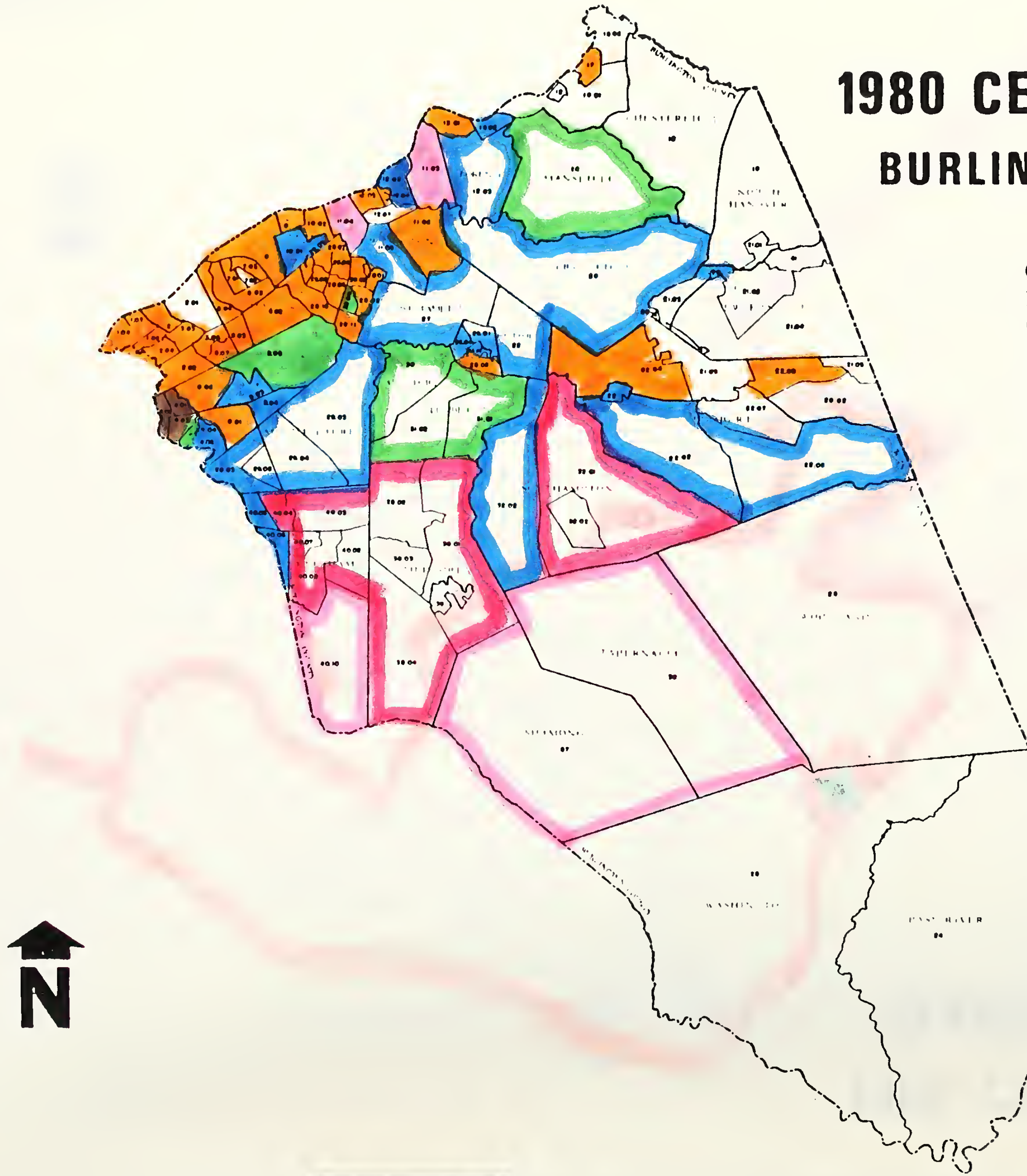
Orange = Ferry
Brown = Collingswood
Green = Westmont
Blue = Haddonfield
Red = Ashland
Pink = Lindenwold
White = not in data set



MAP 2 : STATION CHOICE FOR GLOUCESTER COUNTY

1980 CENSUS TRACTS
BURLINGTON COUNTY

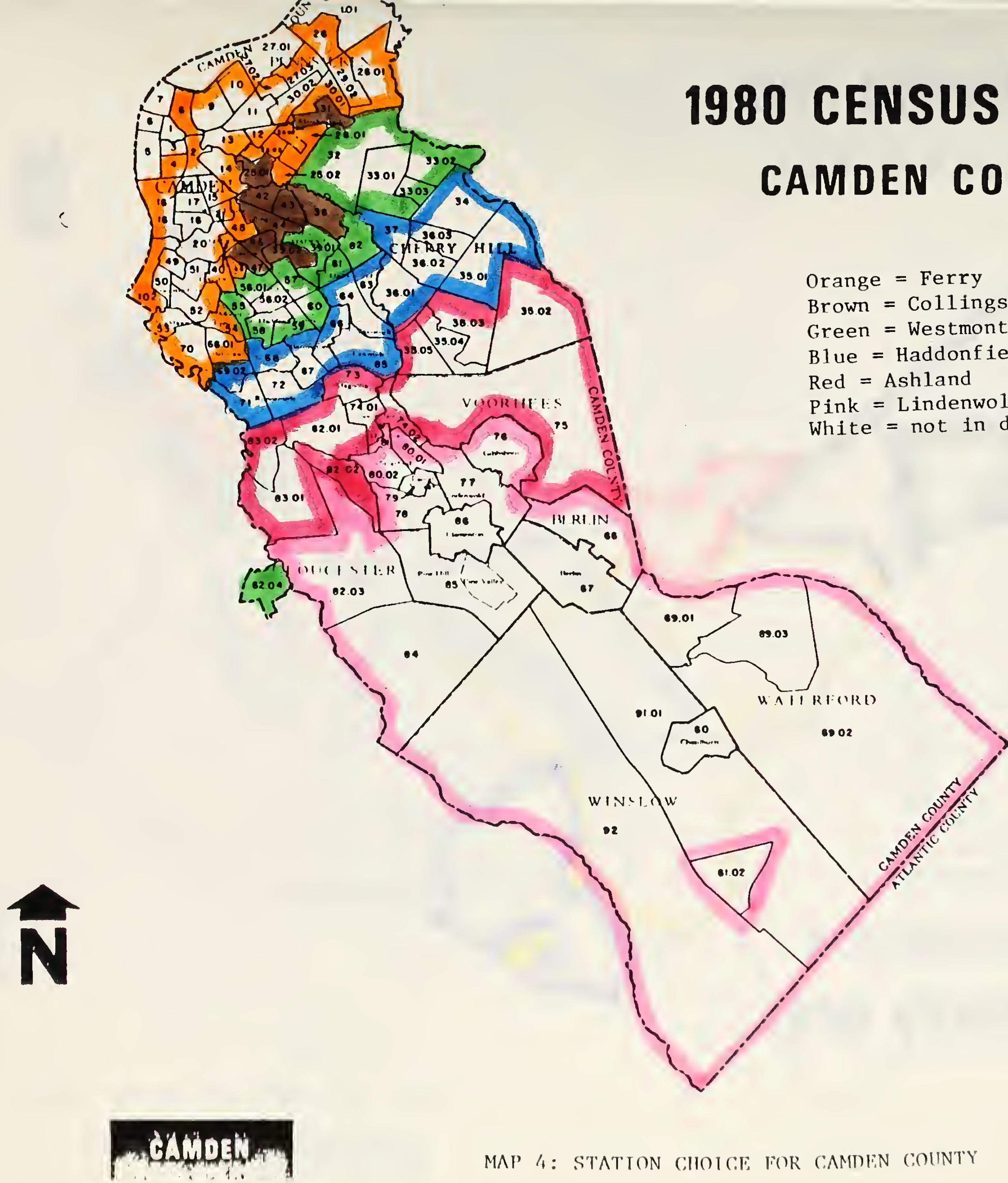
Orange = Ferry
Brown = Collingswood
Green = Westmont
Blue = Haddonfield
Red = Ashland
Pink = Lindenwold
White = not in data set



1980 CENSUS TRACTS

CAMDEN COUNTY

Orange = Ferry
Brown = Collingswood
Green = Westmont
Blue = Haddonfield
Red = Ashland
Pink = Lindenwold
White = not in data set

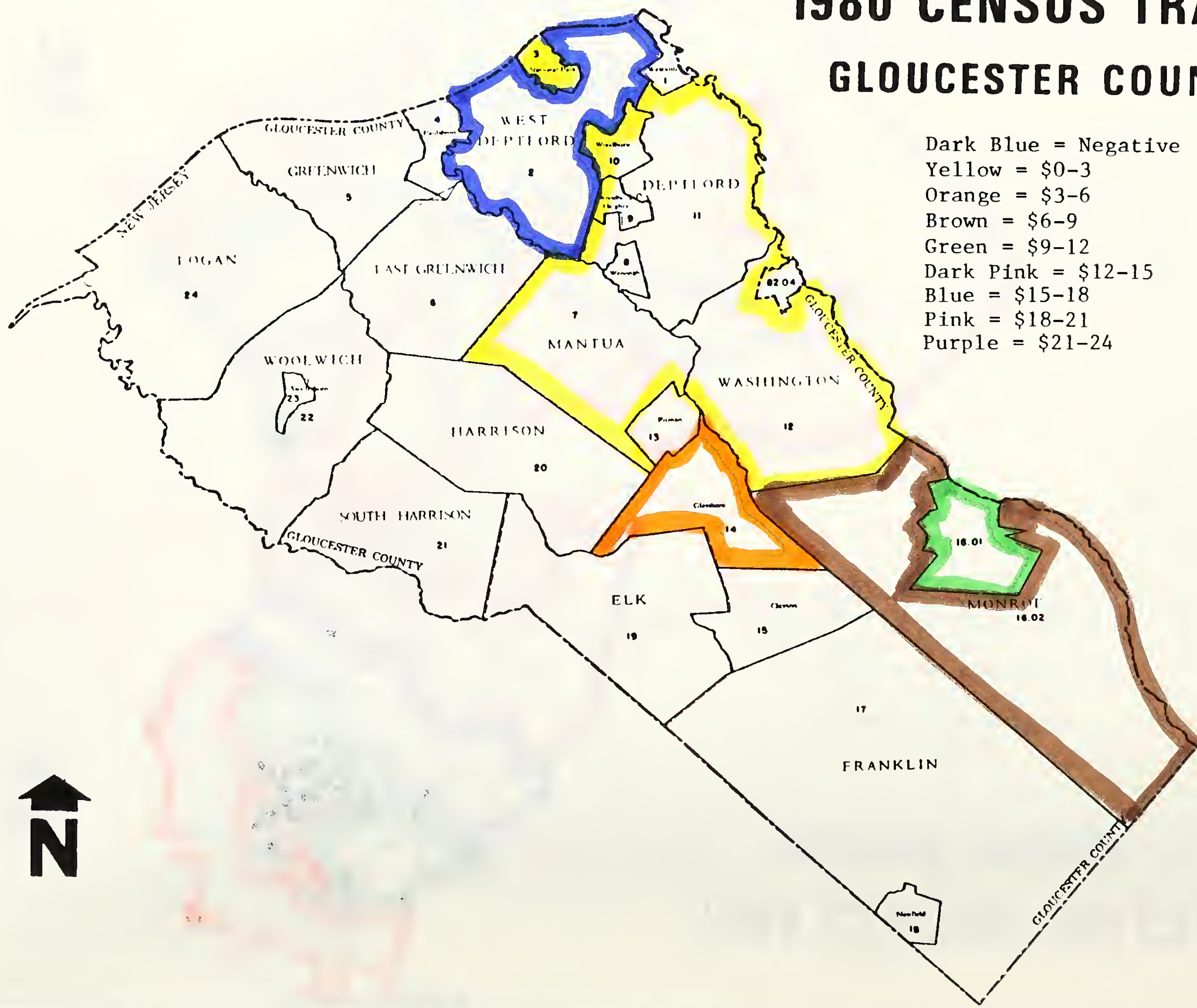


MAP 4: STATION CHOICE FOR CAMDEN COUNTY

1980 CENSUS TRACTS

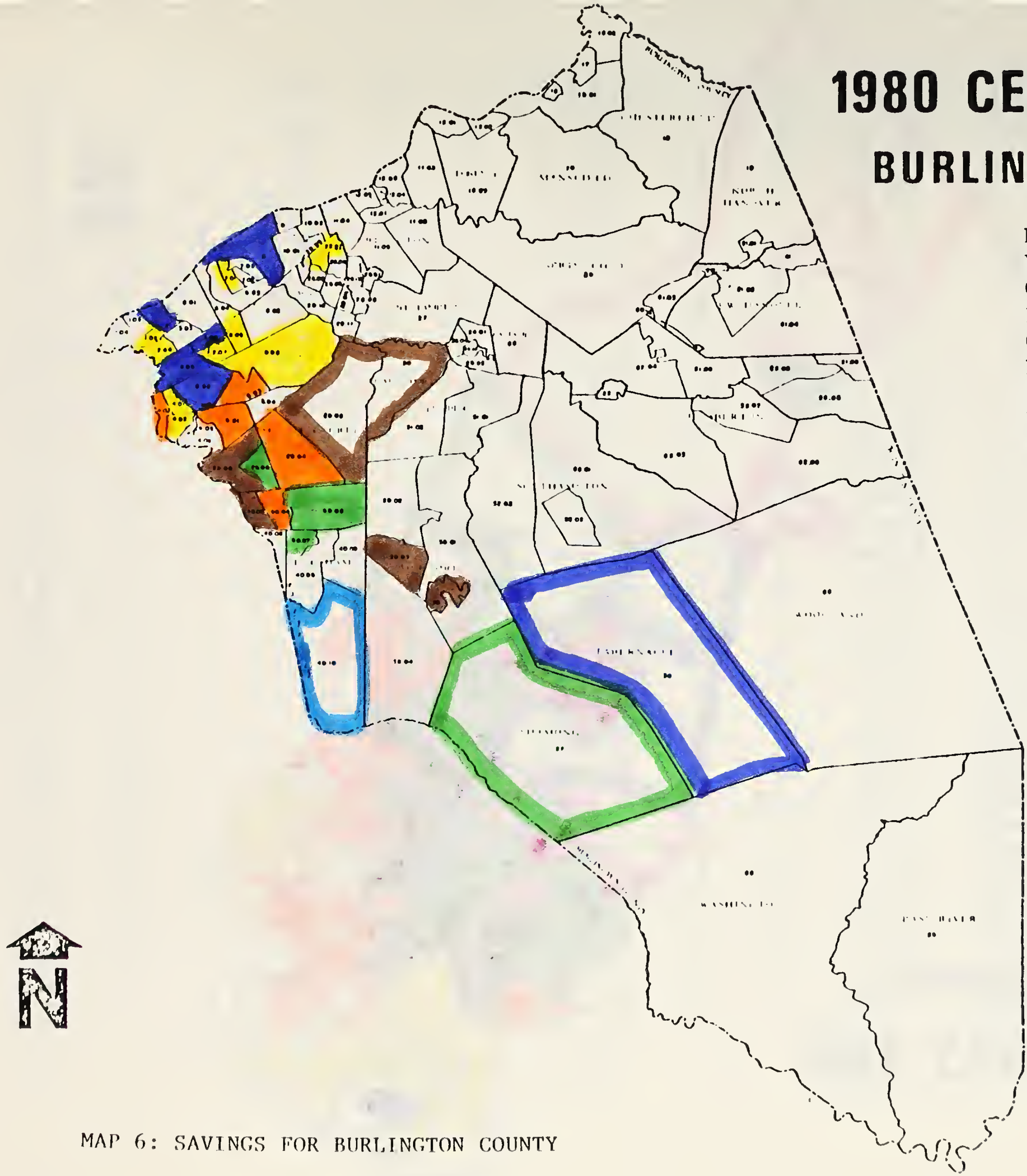
GLOUCESTER COUNTY

Dark Blue = Negative
Yellow = $0-3
Orange = $3-6
Brown = $6-9
Green = $9-12
Dark Pink = $12-15
Blue = $15-18
Pink = $18-21
Purple = $21-24



1980 CENSUS TRACTS
BURLINGTON COUNTY

Dark Blue = Negative
Yellow = $0-3
Orange = $3-6
Brown = $6-9
Green = $9-12
Dark Pink = $12-15
Blue = $15-18
Pink = $18-21
Purple = $21-24



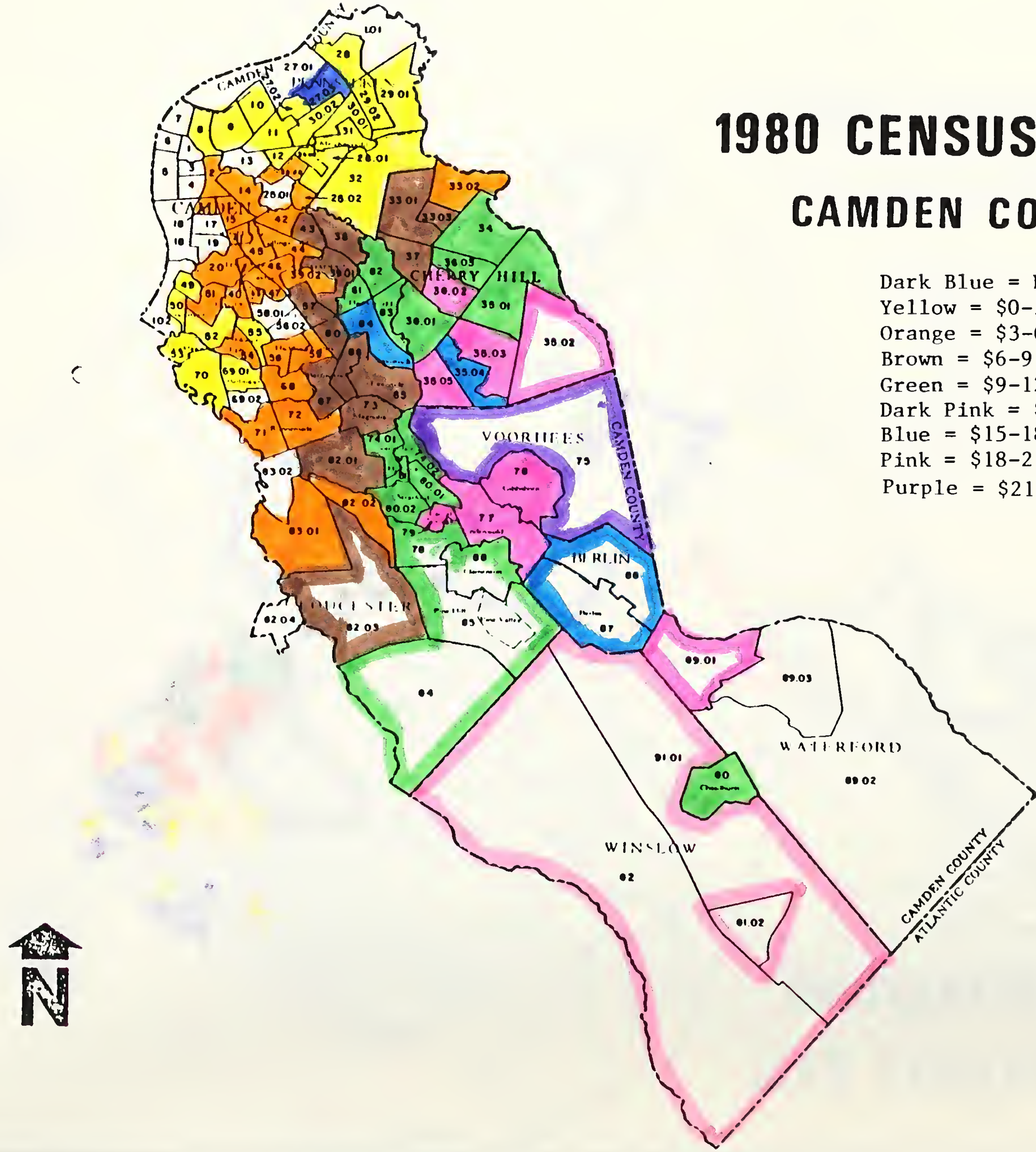
MAP 6: SAVINGS FOR BURLINGTON COUNTY

BURLINGTON

1980 CENSUS TRACTS

CAMDEN COUNTY

Dark Blue = Negative
Yellow = $0-3
Orange = $3-6
Brown = $6-9
Green = $9-12
Dark Pink = $12-15
Blue = $15-18
Pink = $18-21
Purple = $21-24



IV HYPOTHETICAL EXAMPLE OF IMPACT OF SAVINGS ON RENT GRADIENT

In order to show how the improvement in transit will impact on the rent gradient, consider the following scenario. All consumers are the same in terms of utility functions, income, and prices that they face. The lot size is fixed at level L and individuals can only purchase one lot. The population of the metropolitan area is N. The typical Von Thunen assumptions hold, i.e., all employment is in the CBD which is a point H. The auto costs per mile are c and P represents Central Business District (CBD) parking costs. Distance, in miles from the CBD is represented by D_{HX}. The land surrounding the CBD is perfectly homogeneous and transportation can occur in all directions.

Given the above, the area of the city is NL. Since the land is perfectly homogeneous, the city has a circular form. Thus the distance from the CBD to the city's edge is $D^{\wedge}_{HX} = [(NL)/\pi]^{1/2}$.

Rent per unit of land at distance D_{HX} from the CBD is defined by the amount an individual would be willing to pay to avoid paying the transport cost ("full" cost in general, but here only defined as monetary cost for convenience) from the location $D^{\wedge}_{HX}$ less what transportation cost must actually be paid from location D_{HX}. Note that those renting land at the center of the city avoid having to make the round trip from as far away as $D^{\wedge}_{HX}$ to get to work. Thus the opportunity cost of transport of being at the CBD instead of at $D^{\wedge}_{HX}$ is:

(1) $2cD^{\wedge}_{HX} + P$

An individual at location $D^{\wedge}_{HX}$ has to bear the maximum transportation cost. Since the maximum is paid, the land has no scarcity value and hence its rent at $D^{\wedge}_{HX}$ will be its option in agricultural uses, i.e., R_A. R_A will be assumed to be zero herein.

An individual between the CBD and $D_{HX}\hat{}$ at D_{HX_1} will have to pay $2cD_{HX_1} + P$ in transportation costs, but, at the same time, will avoid having to pay $2c(D_{HX}\hat{} - D_{HX_1})$ in additional transport costs by virtue of not living at the city's edge. This residual will be collected by clever landlords as the maximum surplus which the individual has available for rental payments.

Thus the rent function, R, for the above community reads

$$(2) \quad R = 2c(D_{HX}\hat{} - D_{HX})$$

and it declines in a linear fashion from the CBD.

To give a concrete example, suppose that $D_{HX}\hat{} = 5.3$ and $c=1$. The rent function would be $R=10.6 - 2D_{HX}$ after a single point of 14.6 at the CBD given a CBD parking cost of four. The area of the city is 28.2.

Consider now a transit investment with a station four distance units from the CBD (H) at location G, i.e., $D_{HG} = 4$. The fare on the line is four (F).

Driving cost to the CBD can be expressed as (note, all of the costs except for pure monetary driving costs, parking, and transit fare are surpressed in the analysis only for the sake of simplicity. The results are the same, in form, when more variables are added):

$$(3) \quad TC_A = 2cD_{HX} + P$$

while total transit cost is:

$$(4) \quad TC_T = 2cD_{GX} + 2F$$

(in this case D_{GX} is the distance measured from point G).

Equating (3) and (4) and solving for $D_{HX} - D_{GX}$ yields:

(5) $D_{HX} - D_{GX} = \{ [F - (1/2)P] / c \} = K$

where K = 2 given the parameters above.

As the result of the improvement, it is now possible to commute to the CBD from a distance further than 5.3 miles from the CBD at a cost cheaper than 14.6 from within the transit capture area (the transit capture area is the area to the right of K in Figure 3 where transit is cheaper than auto). Consider a point on the line segment HG extended rightward seven distance units from H. The roundtrip driving costs to the station at G would be six and the roundtrip fare on the transit line would be eight for a total transportation cost of 14. Consequently, individuals currently outside of the transit capture area would look at areas within the transit area as attractive locations since land in the transit capture area the same physical distance from the CBD can be travelled from for less than land the same physical distance from the CBD in the auto area, e.g., at five distance units from the CBD, the auto cost in the auto zone is 14 while at five distance units from the CBD in the transit zone, the transit costs are 10.

This enhancement of the land in the transit capture area will increase its attractiveness (and hence bid up its rents) while, at the same time, the auto area zone will decrease in attractiveness and hence its rents will fall. People will move from the auto zone to the transit zone but since the lot size consumed by each individual remains fixed and the population is fixed, the overall area of the city must stay at NL.

In this scenario case, the new city expands to seven distance units from H on the line HG extended and shrinks to five distance units from the CBD in the auto zone. The auto zone and the transit zone intersect three distance units directly above and below the station at G. The post-transit city (solid line) and the pre-transit city (dotted line) appear in Figure 3. The area of the post-transit city is, of course, 28.2.

Consider the rent gradient along the line HW pre and post the transit investment. Previously the gradient was $R = 2c(\hat{D}_{HX} - D_{HX}) = 10.6 - 2D_{HX}$ where $D_{HX} > 0$ with the maximum rent at 14.6 at the CBD ($D_{HX} = 0$). Now the rent gradient is the maximum transport cost (the cost from W or V [the new maximum auto distance of $\hat{D}_{HX}$] which is 14) minus the transport cost from each location D_{HX}. From H to Z, auto is the cheapest mode and

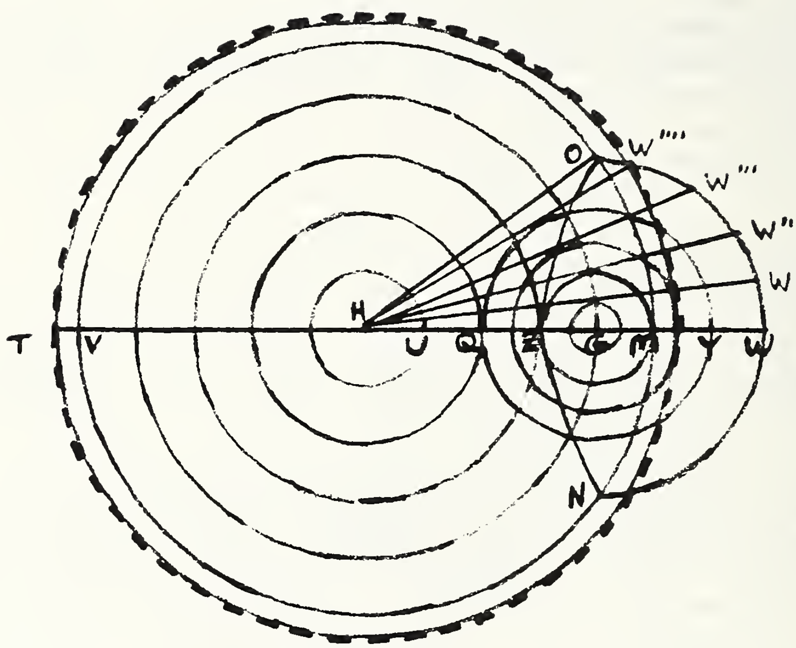


FIGURE 3 : OLD CITY SHAPE (DOTTED CIRCLE) AND NEW CITY SHAPE (BULGING CIRCLE) FOLLOWING A TRANSIT INVESTMENT

thus the rent gradient reads $R = 2c\hat{\hat{D}}_{HX} + P - 2cD_{HX} - P =$

$2c(\hat{\hat{D}}_{HX} - D_{HX}) = 10 - 2D_{HX}$. However, from Z through W, transit is the cheapest with a cost of $2cD_{GX} + 2F = 2D_{GX} + 8$. Thus the rent function reads $R = 2c\hat{\hat{D}}_{HX} + P - 2cD_{GX} - 2F = 2c(\hat{\hat{D}}_{HX} - D_{GX}) + P - 2F$ $= 6 - 2D_{GX}$ (for $D_{GX} \geq 3$) and falls to zero at W.

The pre and post-transit rent gradients are shown in Figure 4.

Savings (S) is defined as auto cost minus speed line cost, i.e..

(6) $S = 2cD_{HX} + P - 2cD_{GX} - 2F = 2c(D_{HX} - D_{GX}) + P - 2F$

or

(7) $D_{HX} - D_{GX} = \{[F - (1/2)P]/c\} + \{S/2c\} = 2 + (S/2)$

Since the maximum $D_{HX} - D_{GX}$ is D_{HG}, the maximum savings in general is $S_{max} = 2cD_{HG} + P - 2F$ or in this case four. Thus the savings range between zero and $2cD_{HG} + P - 2F$ in the transit impact area.

Subtracting the old rent gradient from the new gradient yields:

(8) $\Delta R = 2c(\hat{\hat{D}}_{HX} - \hat{D}_{HX}) + [2c(D_{HX} - D_{GX}) + P - 2F]$

$= S - 2c(\hat{D}_{HX} - \hat{\hat{D}}_{HX}) = S - C$

Thus the savings contours yield exactly the change in daily rent at a given location i from before to after the transit investment minus a component reflecting twice the rate by auto multiplied by the shrinkage of the city in the non-impacted area.

Since market prices are the present value of the future stream of rents, i.e., the capitalization of rents, so, too, would the change in prices of a property reflect a capitalization of savings (adjusted for the shrinkage factor), i.e.,

(9) $(R/i) = SP$

where i = interest rest
SP = sales price

Since $\Delta R = S - C$ and $\Delta SP = (R'/i) - (R/i) = (\Delta R/i)$, then

(10) $(\Delta R/i) = ([S-C]/i) = (S/i) - (C/i)$

Consider Figure 4. While rents increased in the area slightly to the right of Z out to W, they decreased in the area from H to the point slightly to the right of Z (at $D_{HX} = 3.15$).

The net gain to rents along the rent gradient is 6.808. However, consider the rent gradient along the line GH extended leftward from H to T. This corridor is in the auto capture zone. As the result of the transit system, the city shrinks in this area from $D^{\wedge}_{HX}$ to $\hat{D}^{\wedge}_{HX}$, i.e., from 5.3 to 5. The pre-transit rent gradient was $2cD^{\wedge}_{HX} + P - 2cD_{HX} - P = 2c(D^{\wedge}_{HX} - D_{HX})$ while the post-transit rent gradient is $2c(\hat{D}^{\wedge}_{HX} - D_{HX})$. Subtracting the old rent gradient from the new yields $\Delta R = 2c(\hat{D}^{\wedge}_{HX} - D^{\wedge}_{HX}) < 0$ (equals -.6 in this case), since $D^{\wedge}_{HX} > \hat{D}^{\wedge}_{HX}$. This rent gradient is shown in Figure 5.

In this case, the $\Delta R < 0$ and hence there is a loss in this area caused by the transit line. This loss is equal to 39.76 and occurs around the circumference of the circle from N through V to O. (Calculated on the basis of the difference in the volumes of two cones (volume=$[1/3]\pi r^2 h$, where r=radius [in this case 5 and 5.3]

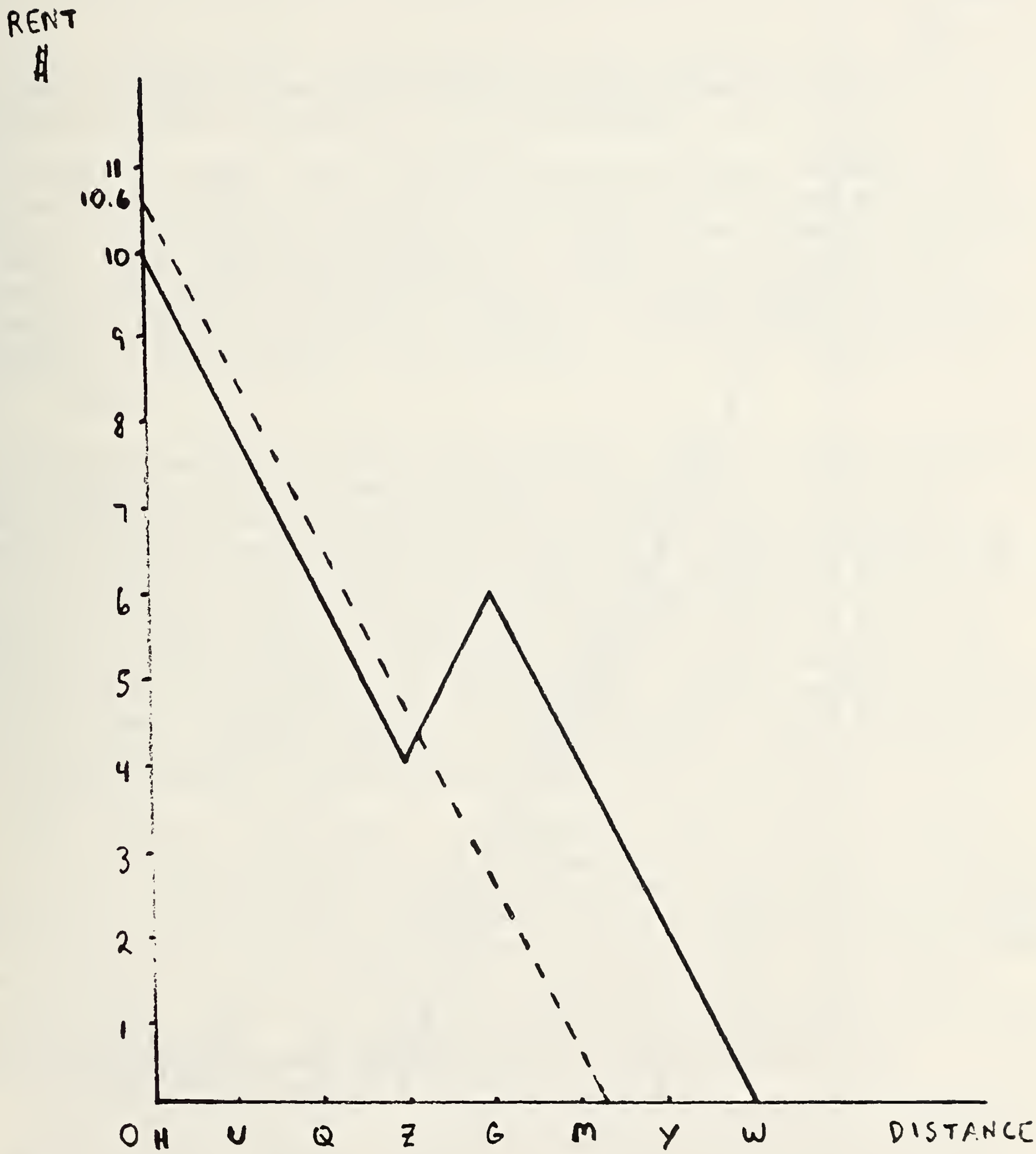


FIGURE 4 : PRE AND POST TRANSIT RENT GRADIENTS ALONG THE TRANSIT CORRIDOR HW

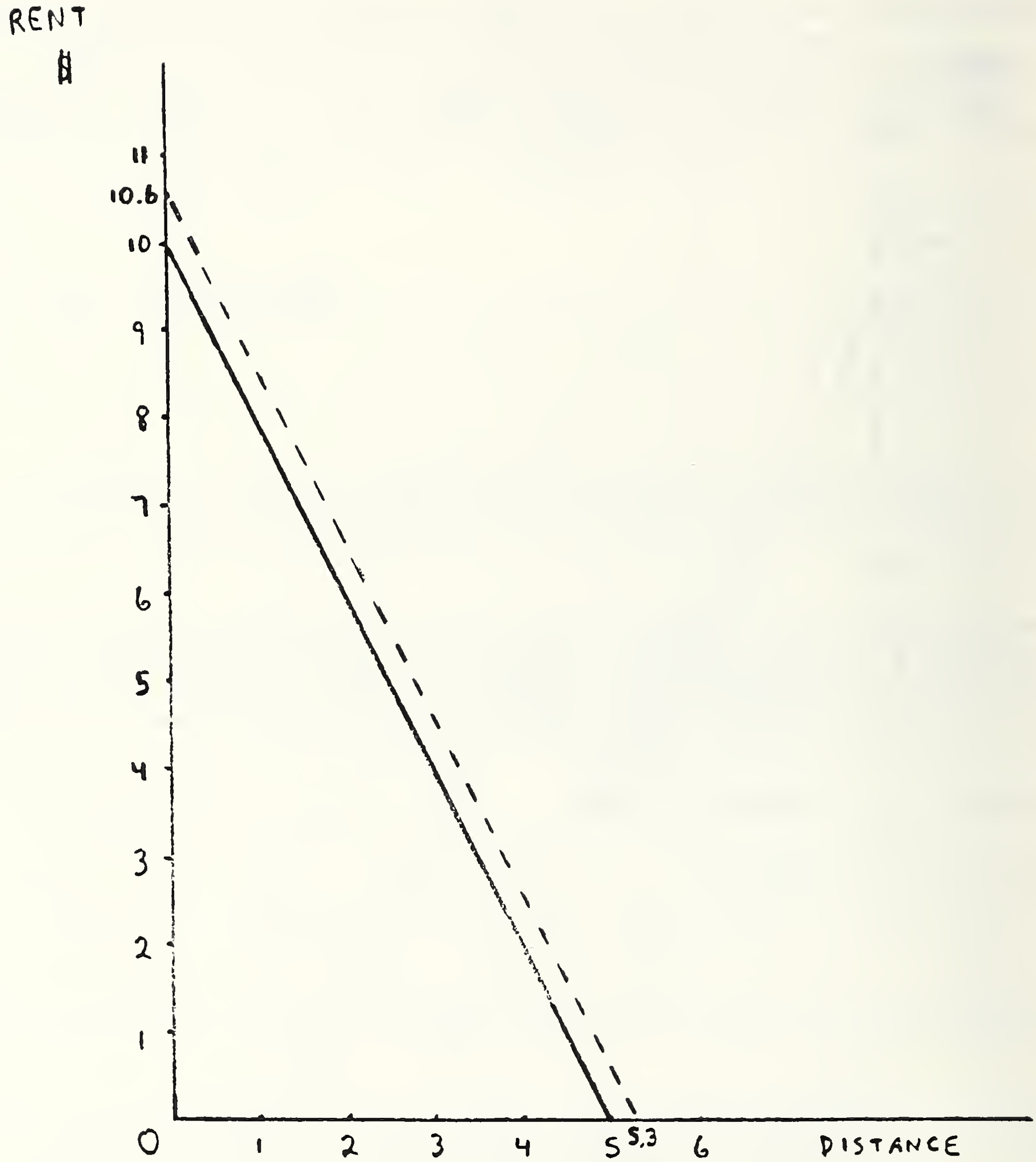


FIGURE 5 : PRE AND POST TRANSIT RENT GRADIENTS IN THE STRICT AUTO USING SEGMENTS OF THE VON THUNEN CITY, I.E., ALONG HT

and h=height [in this case 10 and 10.6]. Since the transit impact area cuts a pie slice of the circular city from HO to HN of 73^{o} 44′, only 79.52% of the difference in the volume is used to describe the rent shrinkage in the N through V to O arc of the city).

On the arc OMN, rent gradients such as Figure 4 exist but the span of domination of auto rent over transit rent is always larger and the span of domination of transit rent over auto rent is always less and always smaller in terms of value than that rent gradient measured along HW. This is because the level of available savings is smaller as the rent gradient swings from an HW gradient down to a HO or HN gradient (i.e., savings decrease from $2c(D_{HG} - K)$ to zero).

Consider several other rent gradients. Only one HW gradient exists. However, two of every other rent gradient within the transit capture area exists (a mirror image of every gradient above the HW line exists below the line). The gradient along HW′ is just tangent to the circle of radius one-half from station G. The rent gradient along the positively sloped section and the negatively sloped section from four distance units to the city periphery are non linear. Two areas exist in the comparison of rent gradients (see Figure 6). In area B, the rent gradient falls while in area D (which contains the positively sloped segment and the negatively sloped segment to the periphery), rents increase. For the HW′ gradient, the D area exceeds the B area for a rent gain of 5.611.

The gradient along HW′′ is tangent to the circle of radius one from station G. The area of B expands and that of D contracts as the rent gradients move toward HO and HN. For the HW′′ gradient, D exceeds B by 4.13 and so aggregate rents increase by that amount. The gradient HW′′′ is tangent to a circle of radius one and a half from station G. In this case, area B exceeds area D by .297 so that aggregate rents fall by .297 along this gradient. The gradient along HW′′′′ is tangent to the circle of radius two from station G. This gradient shows a 2.273 loss in rent. The gradients HO and HN show a 3.196 loss in rent.

Thus within the sector of the circular city which contains the transit impact area, aggregate rents will decrease, e.g., along the HN, HO, HW′′′′, and HW′′′ gradients; will remain the same, e.g., for some gradient between the HW′′′ and HW′′ gradients; and will increase, e.g., along the HW′′, the HW′, and the HW gradients. The greatest increase in aggregrate rents is along the gradient that coincides with the transit line.

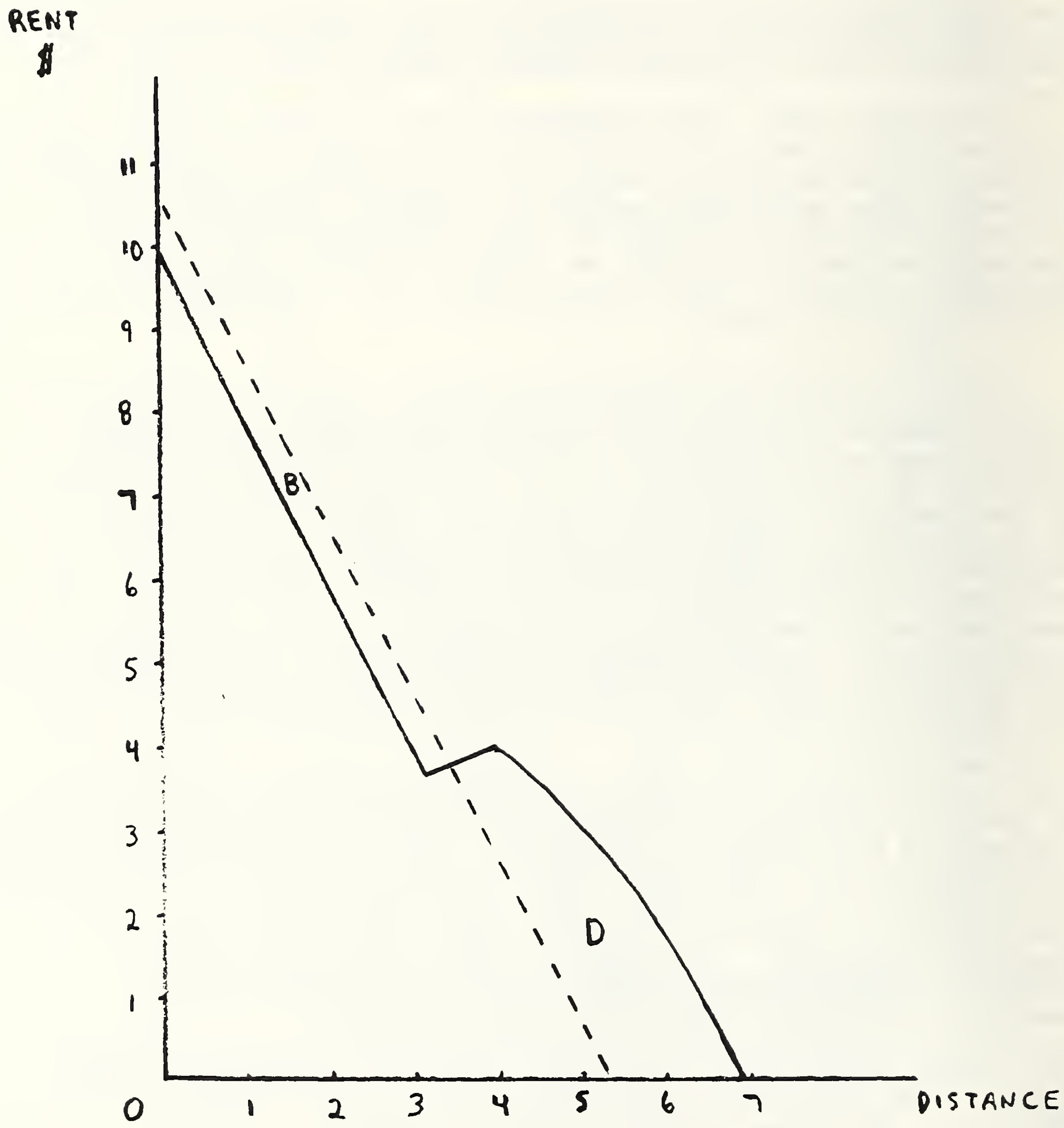


FIGURE 6 : PRE AND POST TRANSIT RENT GRADIENTS ALONG LINE HW' (WHICH IS TANGENT TO A CIRCLE OF RADIUS ONE HALF FROM STATION G)

V VALUE CAPTURE AND THE LINDENWOLD LINE

Following the analysis thus far, the savings for each Census Tract calculated in Section III should be entered into a model to see if it explains sales price as in Section IV.

However, some adjustments must be made. The data collected represents the sales price of improved land--not the change in sales price (discounted change in site rent) of unimproved land. Thus the dependent variable in the analysis is the transaction price of single family residential homes. Since improvements have been made to the land, in order to control for such improvements, they are entered into the analysis as independent variables. A list of such variables appears in Section I. Such inclusion yields hedonic prices for the characteristics of the property.

Since the properties are influenced by the Philadelphia/Camden rent gradient, distance from both the Ben Franklin and Walt Whitman Bridges are included in the analysis to register the presence of the urban rent gradient. The analysis herein is designed to measure how that gradient has been perturbed as the result of the Line.

Characteristics of the neighborhood will also influence housing prices. Characteristics of each Census Tract were taken from the 1980 Census and are listed in Section I. These characteristics are added as independent variables to control for the neighborhood effects.

Finally, the savings variable, as described in Section III is calculated. It becomes the independent variable of interest in the value capture analysis.

Equation (1) reports the results of the regression for the variables with a significant effect:

(1) SALES PRICE= 33,053 - 5,392 Distance to the Ben Franklin
(1.53) (-3.06)

Bridge (in miles) + 4,275 Distance to the Walt Whitman Bridge
(1.98)

+ .1568 Lot Size (in square feet) + 13.18 Property Tax Paid
(4.79) (6.32)

+ 7,492 if house has a garage + 8,277 if house has a
(3.18) (3.51)

fireplace - 15,510 if house has only one bathroom
(-3.96)

- 13,518 if house has only one and one-half bathrooms
(-4.17)

+ 443 Savings
(2.30)

(where the figures in parenthesis are t statistics)

$R^2 = .4177$ $F = 5.27$

The full statistical results are shown in Appendix C. The equation is highly significant as measured by the F. The regression run searched the independent variables for the optimal entrants in terms of contribution to R^2. Obviously, many of the characteristics of the property listed in Section I are not significant and none of the neighborhood characteristics listed in Section I are significant.

The mean sales price is $62,428 (while the mean price in the previous work was $21,260, see, Boyce, Allen, and Tang, 1976). While the intercept is not statistically significant, it is presented as a reference point. The two bridges are used as reference points for the urban rent gradient since heavy traffic on each bridge is oriented toward the Philadelphia CBD. The sum of the two coefficients states that a property equidistant from the two bridges experiences a ceteris parabus drop in housing price of $1,117 for each mile located further from Philadelphia. Property located above the equidistant line falls slower in value as one gets further from Philadelphia while property located below the equidistant line falls faster in value as one gets further from Philadelphia. These results seem plausible given the perceived quality of the areas above the equidistant line.

That larger lot sizes command higher prices is not surprising. Likewise, despite the fact that higher property taxes should be negatively capitalized into sales prices, the value of a house and the property tax on the house are highly positively correlated. This is because property taxes are based on property values and may also relate to the degree of municipal services which the property enjoys. The hedonic price for garages and fireplaces are positive and strong. The bathroom variables are dummies related to a larger than two bathroom house. As can be seen, houses with only one bathroom or a bath and a half are strongly discounted in the market relative to houses with more than two bathrooms.

Finally, the savings variable is strongly significant with a positive coefficient. It states that a dollar's worth of daily savings is worth $443 of sales price for a house. A dollar's worth of transportation "full" cost savings is worth $250 per year (assuming 250 work days per year). This indicates a discount rate of 56.4% assuming that the savings rate would accrue to the property forever (i.e., the pure capitalization hypothesis of Section IV was applied). Obviously, this seems to be a very high discount rate.

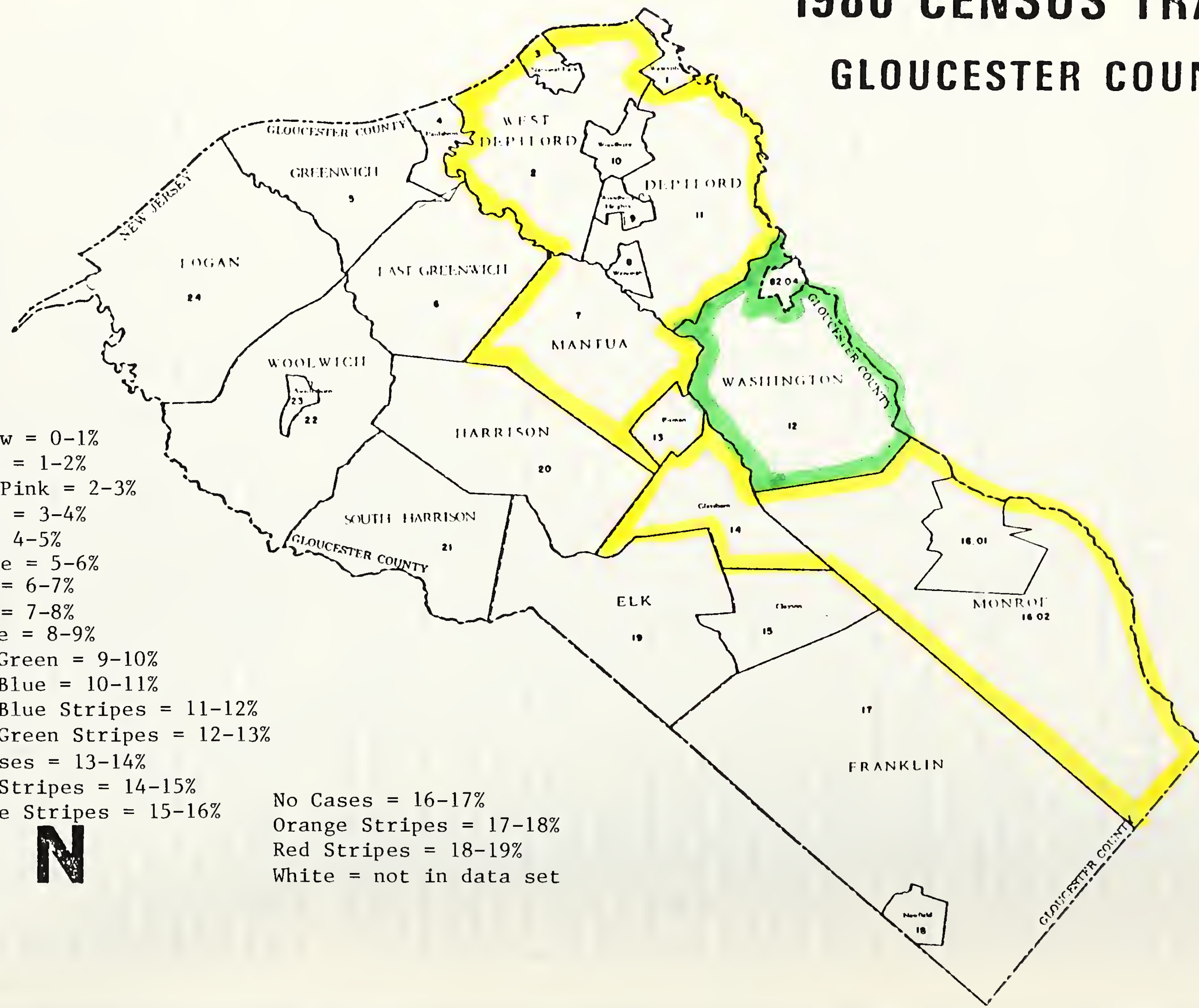
However, there are multiple reasons why the pure capitalization hypothesis should not apply. The first is that which discount rate to use, in general, is difficult to determine. Because of risk and uncertainty of the future, it should likely be a high one. Gasoline prices have doubled in one year in the past and such changes would change the future savings rate, i.e., the level S would not prevail at location X forever. In addition, there is obviously much unexplained variance in sales price which is not explained by the data set. In addition, the pure capitalization effect must be modified downward by the adjustment factor described in Section IV (if Section IV's assumptions hold). However, elastic demands for land and a growing population will violate those assumptions. The assumptions of an elastic demand for land and population growth will, at worst, hold the city's shape in the non-impacted area and cause the city to grow even more in the impacted area. This will tend to hold rents up in the non-impacted area and cause them to grow more than indicated in Section IV in the impacted area. If the demand is elastic enough, rents could grow area-wide (albeit moreso in the impacted area). Thus supply and demand effects are also working in the city. Likewise, the Von Thunen center city dominance does not hold in the case herein. While the Philadelphia CBD is the single largest concentration of employment in the Philadelphia region, it does not hold the majority of the jobs. Sub-regional centers exist and these centers may cause the rent gradient to rise and fall rather than monotonically fall as one gets further from the CBD ceteris parabus.

The average value of savings and the rest of the value capture analysis was calculated in the following fashion. Since 4% of the journeys to work in the nation are by transit, only those Census Tracts which had 4% or more of their journeys to work by the Line were counted as transit Census Tracts (in the three county area, from the Census Tracts which had both users and property transactions, the number is 4.34%. Using 4 or 4.34 yields virtually the same results). If all tracts which had both Line users and real estate transactions were included, the capture value would be 66% higher than that given below. The analysis already had cut some tracts before the transit Census Tracts were defined, i.e., if no users were found to exist from a tract, real estate data was not used from that tract; likewise, some tracts with users were not entered into the analysis because no real estate transactions existed for that tract. Maps 8,9, and 10 show the percent using the Line from the area's Census Tracts.

In the aggregate, a capture tax on all transit contributed value on the single single family residential properties defined as in transit Census Tracts would yield $279.5 million. In the early 1970's, the authors estimated that a value capture tax could raise about $50 million in 1970. This is about half of the cost of constructing the Line. The Line's construction cost vastly understates the construction cost of building the Line from the ground up since the right of way already existed, as did a river crossing to Philadelphia, and tunnels and stations in Philadelphia and Camden. Thus while $50 million was about one half the cost of constructing the Lindenwold Line, it is a much smaller share of the costs of constructing the system from the beginning.

If the $50 million is inflated from 1970 dollars to 1980 dollars (by the Consumer Price Index), it represents $102.5 million as compared to the $279.5 million calculated herein. The Line itself would cost $237 million to construct today assuming the same conditions as in 1968.

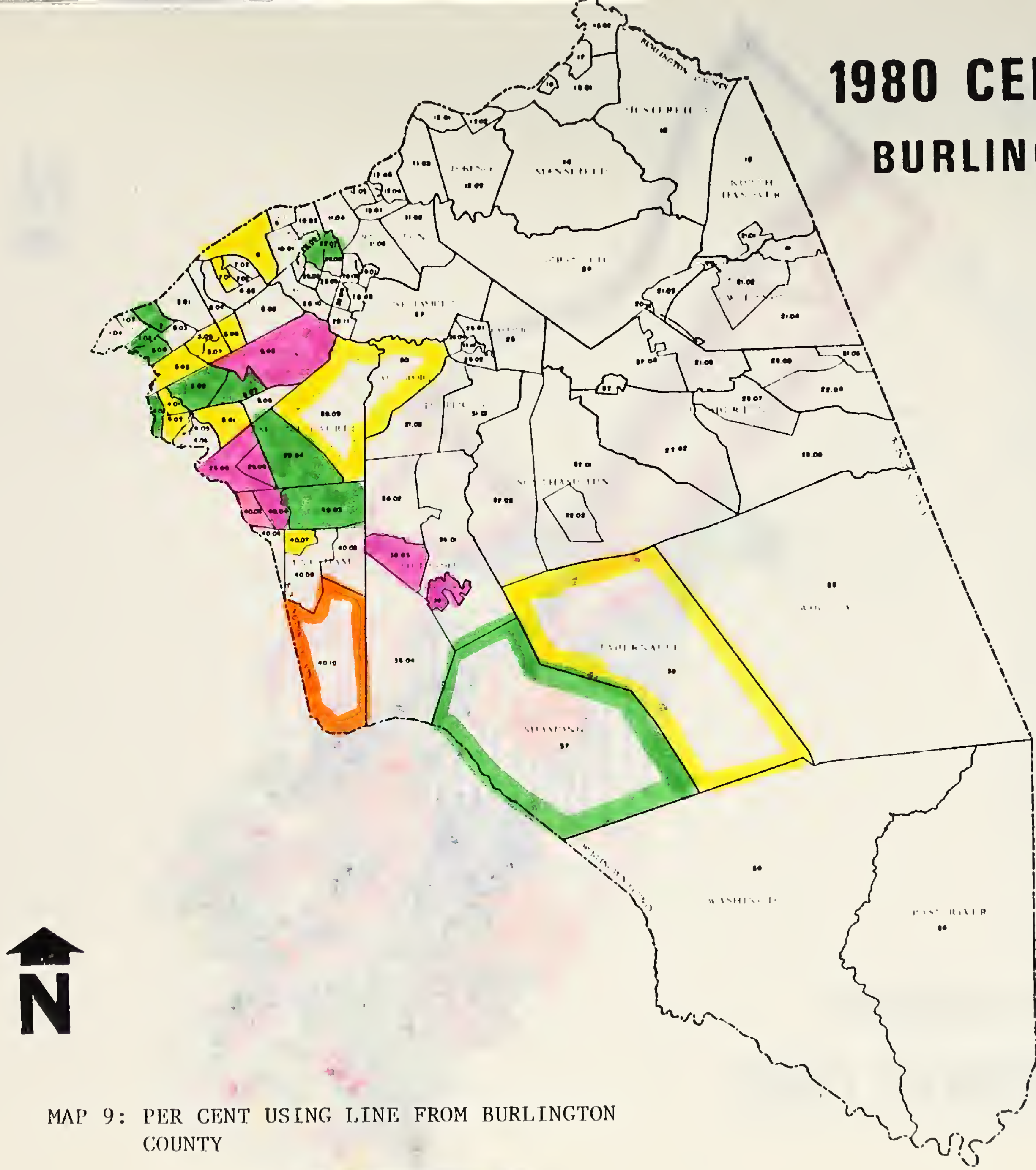
1980 CENSUS TRACTS
GLOUCESTER COUNTY



Yellow = 0–1%
Green = 1–2%
Dark Pink = 2–3%
Brown = 3–4%
Red = 4–5%
Orange = 5–6%
Blue = 6–7%
Pink = 7–8%
Purple = 8–9%
Dark Green = 9–10%
Dark Blue = 10–11%
Dark Blue Stripes = 11–12%
Dark Green Stripes = 12–13%
No cases = 13–14%
Pink Stripes = 14–15%
Purple Stripes = 15–16%
No Cases = 16–17%
Orange Stripes = 17–18%
Red Stripes = 18–19%
White = not in data set

1980 CENSUS TRACTS

BURLINGTON COUNTY



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Orange = 5-6%
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Dark Green = 9-10%
Dark Blue = 10-11%
Dark Blue Stripes = 11-12%
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Purple Stripes = 15-16%

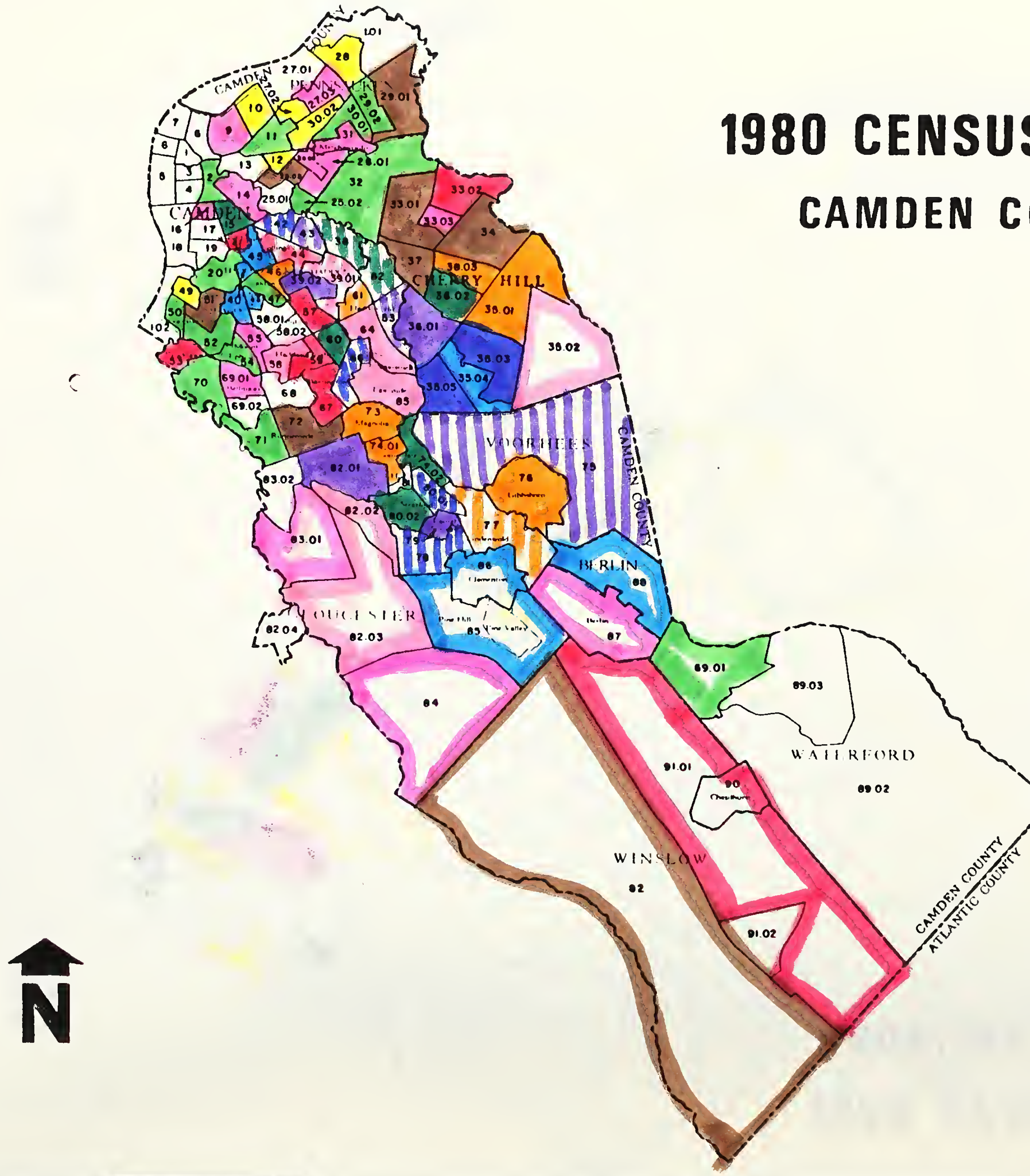
No Cases = 16-17%
Orange Stripes = 17-18%
Red Stripes = 18-19%
White = not in data set

MAP 9: PER CENT USING LINE FROM BURLINGTON COUNTY

BURLINGTON

1980 CENSUS TRACTS

CAMDEN COUNTY



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Orange Stripes = 17-18%
Red Stripes = 18-19%
White = not in data set

It must be stressed that this value capture analysis has numerous problems. One of the largest ones is the lack of a value of time locally generated by a station choice model. Another is the fact that the model only explains 40% of the variance of the sales price (not atypical for these types of models). Thus the conclusions should be viewed as tentative on a quantitative basis. However, on a *qualitative* basis, a series of models have been developed with the capability of producing value capture numbers and have shown that, in this geographic market, a significantly large amount of value was available to be captured.

VI CONCLUSIONS

The research described herein developed simple modal choice, station choice, and savings models all from the economic laws of market areas analysis. The simple models described herein can all be made more complicated by the addition of actual road networks and congestion thereon. In fact, the actual empirical calculations of distance and times from Census Tracts to stations were made by the DVRPC on their highway network of the region. The interdependence of all three models was also demonstrated. The change in the rent structure in a Mohring city was demonstrated when a transit corridor was introduced in a previous all auto city.

The models were then tested using data collected showing where the auto users of each station originated their trips and the transactions prices of single family houses in the Lindenwold capture area.

The value capture regression showed that savings were capitalized into the property values such that each dollar's worth of daily savings added $443 to the value of the property. The average savings was $10.34 implying that $4,581 is available to be captured per single family dwelling unit. With 61,021 dwelling units in the transit Census Tracts, the level of value to be captured is of the magnitude of $279.5 million. This figure is 117.9% of the construction costs of the Line (such costs inflated to represent 1980 dollars). As pointed out above, such construction costs were low relative to other systems in that tunnels in Philadelphia and Camden and a Delaware River bridge crossing did not have to be built and the right of way was already in place. Had such costs been incurred, the Line would have cost approximately $820 million in 1980 dollars. This would place the above value capture percentage in the one third range. This is still a high number relative to the results of Anas. Of course, in this study, the fall in rents elsewhere are not included in the analysis.

It seems likely that the impacts of "what might have been" in non-impacted areas are likely to be quite small for any individual property and very difficult to substantiate. Thus such rent decreases or lack of rent increases as high as they might have been do not provide a strong case for disbenefits. On the other hand, the property in the transit corridor is likely to experience measurable benefits whose measurement can be made by acceptable (and applied) statistical techniques, i.e., econometric assessment.

Since multiple family dwelling units, commercial property, vacant land, and single family residential units in non-transit Census Tracts (but still with transit use) have been excluded from the analysis, higher value to be captured would seem to exist. In addition, a level of savings which valued auto access time at 74% of the income rate for transit users (just as they value their in-transit vehicle time), yielded value capture levels over 30% higher than those used herein and a statistically significant savings coefficient of $622 for every dollar's worth of savings. Such a value of time assumption leads to appreciably higher savings levels for most Census Tracts.

However, as stressed above, the model suffers from a lack of internally generated values of time, and only explains 40% of the variance in sales prices (typical of such models). Thus the results herein should not be judged on a quantitative basis. Rather qualitative statements are appropriate--such as a series of models exist which can be used to yield value capture magnitudes if the data is available and that subject to the data which was available for this case, significant value was available to be captured.

A policy of value capture for the Lindenwold Line *at this time* would cause great equity problems. If a property holder has *not* transacted his/her property from before the announcement/opening of the Line, then the holder of the appreciated property is the beneficiary and could be taxed. However, if the property has transacted, it is the seller, who held the property from before the announcement/opening and sold after the announcement/opening, who has captured the benefit. The current occupant, if required to pay a value capture tax, would be paying for the same benefit twice. Another problem is that the gain is an unrealized capital gain until the property is sold. For a propertyholder with no other assets, a value capture tax on the property may require the sale of one's home.

This does not mitigate the conclusion that there is value to be captured. It only states that the current occupants are only a subset of the beneficiaries. Thus the time to implement a value capture tax is when the beneficiaries are occupying the property. This would be between the announcement and the opening of the system. This still provides some difficulty because announcement still entails uncertainty about the level and surety of the savings (as well as a discount effect because the savings will only first be realized in the future). Opening provides certainty but some property may already have been transacted. While some researchers have investigated these impacts, more work needs to be done.

Likewise, more work should be done on value capture. It appears to have the ability to raise significant amounts of money--money which is a windfall to property owners who benefit from taxpayer expenditures on transit projects.

The theory that has been developed herein is different from that developed by others relating to value capture with the exception of Mohring and Moses. On a spatial basis, the model developed herein is continuous, while those of Strotz and Lind assume two, in the case of Strotz, or n, in the case of Lind or Anas, distinct pieces of land. Other models don't treat corridors or the continuous nature of space as is explicit herein, e.g., Wheaton, Pines et. al. The analysis herein is partial, based on a transit corridor, while that of Strotz, Lind, Anas, Wheaton, Pines and Weiss is general equilibrium in nature. While a global analysis is desirable, the objective herein was to look for concentrated beneficiaries rather than diffuse (and small) losers of welfare. In the empirical analysis, all models look at discrete parcels of land in their attempt to explain land values, e.g., Dewees; Damm, Lerman, et. al.; Ferguson, Goldberg, and Mark; but all use distance from the transit line, and distance from the transit station as opposed to travel savings as an explanatory variable. Only Anas, in a simulation, has utilized modal split analysis to determine impact.

While the theory herein differs from that developed by others, the conclusion differs more in magnitude. No one is saying that value capture produces no revenue. Some say it is not much. In this case, in this corridor, the magnitude appears to be significant.

APPENDIX A

DERIVATION OF THE MODAL CHOICE, STATION CHOICE, AND SAVINGS MODELS OF SECTION III

Following the assumptions stated in Section III, the notation below applies:

F_i = the fare on the transit system from station i to the CBD (assumed to increase with distance)

W = wait time for the transit system (assumed to be the same at all stations)

T_i = line haul time on the transit system from station i to the CBD (assumed to increase with distance)

V_1 = value of the commuter's time (assumed to be the same for all individuals)

A_T = other amenities associated with transit

V_T = value of the amenities associated with transit (assumed to be the same for all individuals)

c = auto driving cost per mile (assumed to be the same for all drivers regardless of distance driven, type of car, direction driven, or time of day)

m = auto miles per hour (assumed to be the same for all drivers regardless of distance driven, type of car, direction driven, or time of day)

P_A = parking costs associated with auto in the CBD (assumed to be the same for all)

P_T = parking costs associated with auto at the transit station (assumed to be the same at all stations)

B = other pure monetary costs not associated with distance associated with driving (e.g., bridge tolls)

A_A = other amenities associated with auto (assumed to be the same for all users)

V_A = value of auto amenities (assumed to be the same for all users)

E_T = egress cost in CBD for transit (assumed to be the same for all users)

E_A = egress cost in CBD for auto (assumed to be the same for all users)

N_T = egress time in CBD for transit (assumed to be the same for all users)

N_A = egress time in CBD for auto (assumed to be the same for all users)

D_{GX} = straight line distance from location X to station G

D_{HX} = straight line distance from location X to the CBD, i.e., H

D_{HG} = straight line distance from G to H

TC_A = full cost by auto

TC_{Ti} = full cost by transit from station i

Full transit costs (TC_{Ti}) and auto costs (TC_A) are as follows:

$$(1)\quad TC_{TG} = 2F_G + 2V_1(T_G + W) + 2V_T A_T + 2cD_{GX} + 2(V_1/m)D_{GX} + P_T + 2E_T + 2V_1 N_T$$

$$(2)\quad TC_A = 2cD_{HX} + 2(V_1/m)D_{HX} + 2B + P_A + 2V_A A_A + 2E_A + 2V_1 N_A$$

Equating equations (1) and (2) yields the locus of all points X where an individual will be indifferent between using the automobile and using transit.

$$(3)\quad D_{HX} - D_{GX} = \frac{F_G - B + [(P_T - P_A)/2] + V_1(T_G + W + N_T - N_A) + (E_T - E_A) + (V_T A_T - V_A A_A)}{c + (V_1/m)}$$

With knowledge of all of the items on the right hand side of (3), the right hand side would be a constant K and could be described as:

$$(4)\quad D_{HX} - D_{GX} = K$$

If the right hand side variables varied in a particular fashion, e.g., the value of time with income level, the model could be run to apply to certain economic strata which, under the assumptions that initial locations are established, would be highly correlated to certain areas and hence distances from the CBD.

Equation (4) gives the equation of a hyperbola which bends around G if K is positive and around H if K is negative. The larger K is in absolute value, the closer the vertex of the hyperbola is to the points G or H and the "tighter" the bend of the hyperbola around G or H. The hyperbola collapses to a straight line and its vertex is at G or H when $D_{HG} = |K|$. The hyperbola is the perpendicular bisector of the line HG when K=0. No hyperbolas exist when $D_{HG} < |K|$, i.e., either all trips are by auto or all trips are by transit.

The model resulting from (4) is a modal split model. Its form appears in Figure 1 in Section III assuming $0 < K < D_{HG}$. The equation represents the locus of all points X where a person located at X is indifferent between driving or using the transit system. All persons residing to the right of the hyperbola will use the transit line (because it is cheaper than auto, i.e., $TC_{TG} < TC_{A}$), and all individuals residing to the left of the hyperbola will use auto because $TC_{A} < TC_{TG}$.

More stations are easily added to the analysis. Consider station I located beyond station G. A comparable equation to (3) could be calculated between auto and transit users of station I (under the assumption that those were the only two choices available). This yields (5):

$$(5)\ D_{HX} - D_{IX} = K' > K$$

since the fare from I to H would be expected to exceed the fare from G to H, the time on the transit system from I to H would be expected to exceed the time from G to H, and the amenities on the transit system from I to H would be expected to exceed the amenities from G to H.

If the fare on the line is strictly proportional to distance, then the hyperbola between I and H will merely be parallel and to the right of the hyperbola between G and H. Thus the addition of the station at I will not change the modal split but will change how some transit riders will access the transit system.

If, however, the transit fare structure has a distance taper, i.e., has a fixed component independent of distance and then either increases proportionately with distance or increases at a decreasing rate with distance, then the hyperbola associated with the I to H situation will have its vertex to the right of the G to H hyperbola but will be less "tight" with respect to I than the G to H hyperbola is with respect to G and hence will intersect it and thus allow for the new station to add additional transit riders to the system diverted from the auto users. This is shown in Figure 7 (see area R).

The market area between two stations is found by equating TC_{TG} and TC_{TI} which yields:

$$(6)\quad D_{GX} - D_{IX} = \frac{(F_I - F_G) + V_1(T_I - T_G) + V_T(A_{TI} - A_{TG})}{c + (V_1/m)} = \frac{\Delta F + V_1 \Delta T + V_T \Delta A}{c + (V_1/m)}$$

$$= K' - K = \hat{K}$$

assuming $W_I = W_G$ and $P_{TI} = P_{TG}$. This market area equation runs between Z_1 and Z_2 in Figure 7 (dotted line). Those in the transit area lying to the right of the market area boundary between station G and station I will use station I while those to the left of the boundary, but within the transit market area, will use station G.

Should various neighborhoods be traversed where the value of time changes, differentiating (6) with respect to V_1 yields:

$$(7)\quad \frac{\partial \hat{K}}{\partial V_1} = \frac{c(T_I - T_G) - [(F_I - F_G)/m] - V_T[(A_{TI} - A_{TG})/m]}{[c + (V_1/m)]^2}$$

which is $\gtrless 0$ as $cm(T_I - T_G) \gtrless (F_I - F_G) + V_T(A_{TI} - A_{TG})$.

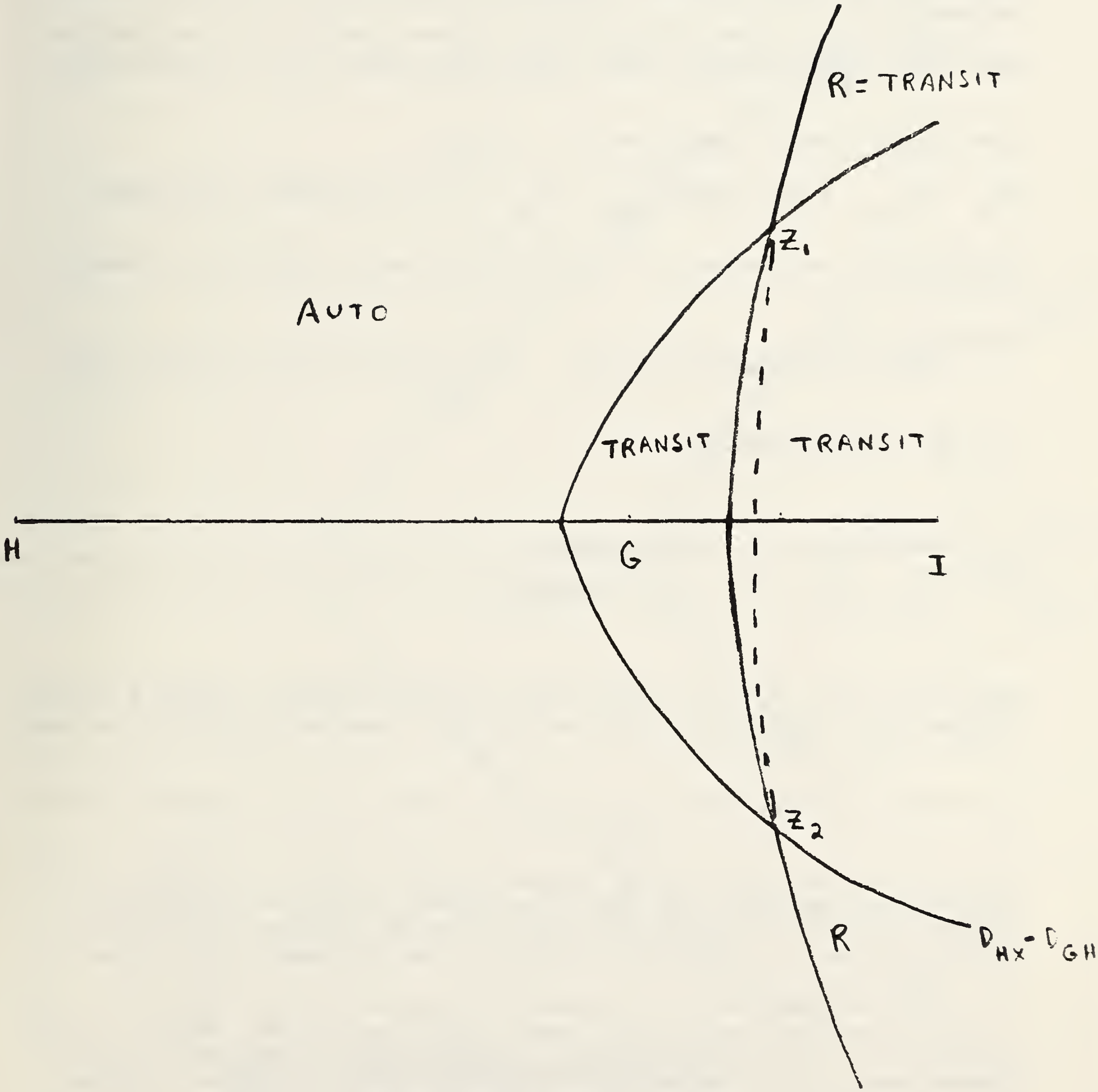

FIGURE 7 : SIMPLE STATION MARKET AREAS AND
MODAL SPLIT AREAS ASSUMING A
TRANSIT FARE DISTANCE TAPER

Clearly (7) can be positive, negative, or zero. Thus the market areas may increase, decrease, or stay the same as the value of time changes from area to area (read income group to income group). Thus the transit market area may increase or decrease as the value of time (income) increases depending on the parameter values.

Consider a level of savings S where savings are defined as auto cost minus transit cost. The area where $S \geq 0$ is obviously the transit market area and S = 0 where $D_{HX} - D_{GX} = K$ and where $D_{HX} - D_{IX} = K'$ in the area (R) where (and if) K′ dominates K, i.e., from Z_1 and Z_2 and beyond should station I exist.

Since S is defined as $TC_A - TC_{TG}$ for the one station case, it can be rewritten as:

$$(8) \quad D_{HX} - D_{GX} = K + \frac{S}{2(c + [V_1/m])} = \tilde{K}$$

Thus, when S = 0, (8) is the modal split boundary. Since $\tilde{K}$ cannot exceed D_{HG}, $S_{MAX} = 2(c + [V_1/m])(D_{HG} - K)$ and by varying S between zero and $2(c + [V_1/m])(D_{HG} - K)$, the locus of all points X which incur equal savings can be traced by (8). This will appear as in Figure 2 in Section III. Thus the beneficiaries of a transit investment can be spatially identified by savings level by the method above. For multiple stations, the savings locii appear as in Figure 8.

The savings mentioned above accrues to every property in the transit capture area at the level specified in (8). While (in the real world) not every occupant of property at location X avails themselves of the savings by using the transit system (some may drive because of their misperception of the variables in the model, some may have different parameters than those specified in the model, some may not be able to use the system [handicapped], some may make their decisions based on variables not included in the model, some may not work in the area served by the transit system, some may need their car in their work, etc.), each

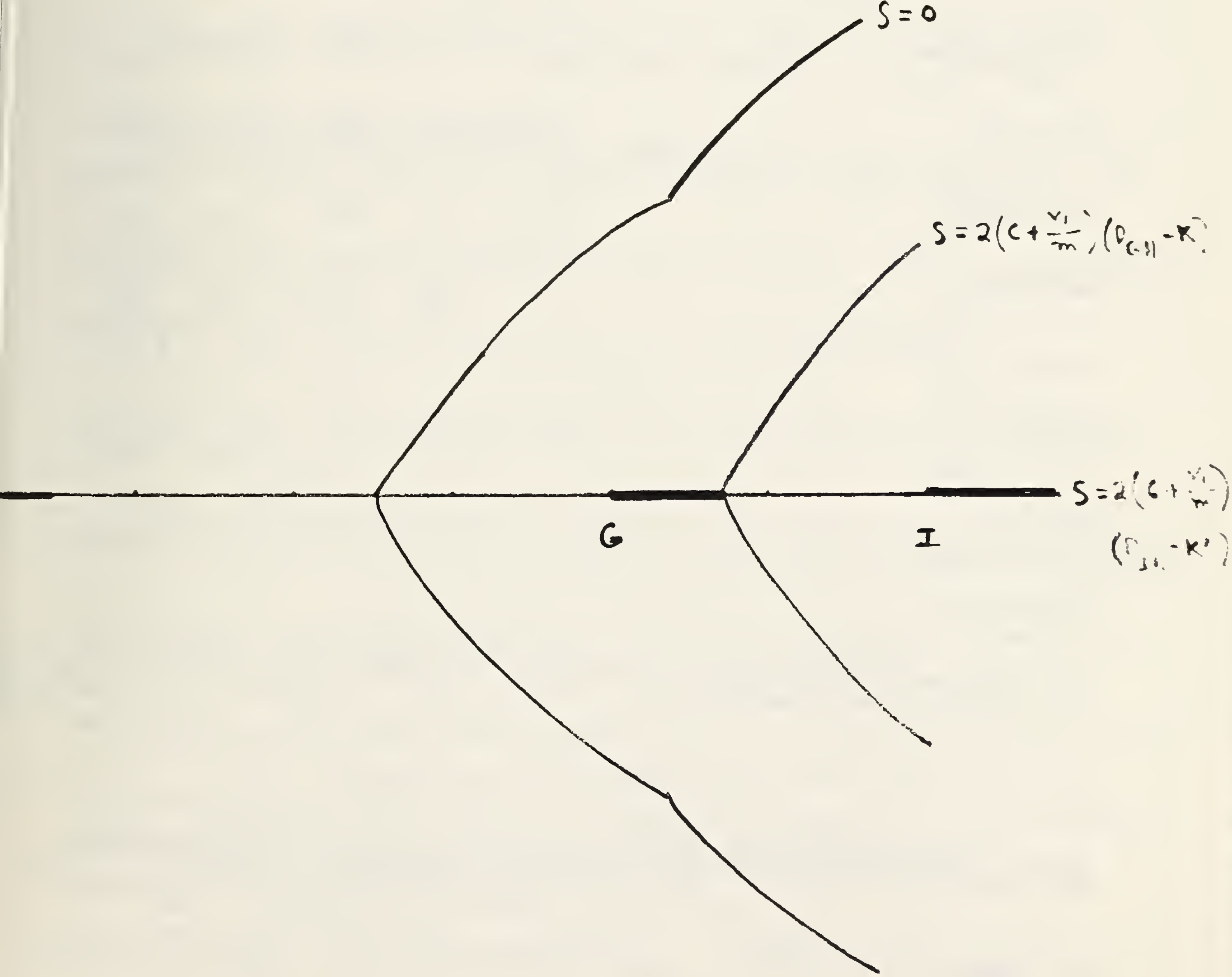

FIGURE 8 : EQUAL SAVINGS LOCII WHEN TWO STATIONS EXIST

location in the capture area has the potential of saving S to some potential user. Hence, each piece of land has an opportunity value of S in savings whether it is realized by the current occupant of the property or not.

The following relationships exist between the actual stations in terms of the K's described above:

	(P)	(F)	(C)	(WE)	(H)	(WO)	(A)	(L)
Philadelphia CBD (P)	-	K_{PF}	K_{PC}	K_{PWE}	K_{PH}	K_{PWO}	K_{PA}	K_{PL}
Ferry Ave. (F)	-	-	K_{FC}	K_{FWE}	K_{FH}	K_{FWO}	K_{FA}	K_{FL}
Collingwood (C)	-	-	-	K_{CWE}	K_{CH}	K_{CWO}	K_{CA}	K_{CL}
Westmont (WE)	-	-	-	-	K_{WEH}	K_{WEWO}	K_{WEA}	K_{WEL}
Haddonfield (H)	-	-	-	-	-	K_{HWO}	K_{HA}	K_{HL}
Woodcrest (WO)	-	-	-	-	-	-	K_{WOA}	K_{WOL}
Ashland (A)	-	-	-	-	-	-	-	K_{AL}
Lindenwold (L)	-	-	-	-	-	-	-	-

However, despite the existence of 28 equations: (seven are of the form [simplified from equation (3)]: $K_{Pi}=[F_i-(1/2)P]/c$, i=F,C,WE,H,WO, A,L, and 21 of the form [simplified from equation (6)] $K_{ji}=(F_i-F_j)/c$, j,i=F,C,WE,H,WO,A,L and i>j), only seven equations are independent. For instance, given K_{PL}, K_{FL}, K_{CL}, K_{WEL}, K_{HL}, K_{WOL}, and K_{AL}, all of the remaining K_{Pi} and K_{ji} can be determined, e.g., $K_{PL}=[F_L-(1/2)P]/c$ and $K_{FL}=(F_L-F_F)/c$ so that $K_{PL}-K_{FL}=K_{PF}=[F_F-(1/2)P]/c$ and $K_{WOL}=(F_L-F_{WO})/c$ and $K_{AL}=(F_L-F_A)/c$ so that $K_{WOA}=(F_A-F_{WO})/c$, etc.

Another way of viewing the same thing is that each station market area K_{ji}, i,j=F,C,WE,H,WO,A,L, i>j, can be expressed as $K_{ji} = K_{Pi} - K_{Pj} = K_{jk} - K_{ik}$. Knowing seven of the elements of the above matrix, including at least one K_{Pi}, will determine all of the other K_{Pj} and K_{ji}. However, without the knowledge of at least one K_{Pi}, the determination cannot be made.

For instance, the intent of the empirical work to be described herein is to estimate all 21 values of the K_{ji}. Despite this knowledge, the remaining seven K's of the form K_{Pi} cannot be estimated (although their differences, $K_{Pi} - K_{Pj}$, can be estimated).

Unfortunately, in order to estimate the savings level for each location, a K_{Pi} estimate is needed.

The problem can be seen as follows. As shown in (8), the savings analysis entails the market boundary, K, plus the savings variable, S, divided by some parameters of the analysis. This yields a new K ($\tilde{K}$). The K in (8) is a modal split K, i.e., a K_{Pi}. Since K_{Pi} cannot be expressed as the difference between two K_{ji}, the savings locii of the system cannot be traced and the savings attributable to each location cannot be given from the empirical model proposed herein.

The auto cost equation used is shown in equation (9) and its parameters were discussed in Section III.

(9) $\text{AUTO COST} = \$6.2272 + \$.1574\, D_{PX} + (.0851063)\, V_{1A}\, D_{PX}$

The costs of using each one of the stations (ST) is formally stated as:

(10) $\text{TRANSIT COST} = 2cD_{STX} + 2(V_{1T_1}/m)D_{STX} + 2F_{ST} + P_{ST}$

$+ 2V_{1T_2}T_{ST} + 2V_{1T_3}W_{ST} + 2V_{1T_4}T_{WST}$

where c and m are defined as in auto cost

V_{1T_1} is auto in-vehicle value of time for a transit user, i.e., 1.78 V_{1T}

V_{1T_2} is transit in-vehicle value of time, i.e., .74 V_{1T}

V_{1T_3} is transit expected wait value of time, i.e., 1.65 V_{1T}

V_{1T_4} is transit access/egress walk value of time, i.e., 3.38 V_{1T}

V_{1T} mean yearly income of Census tract/2080

D_{STX} is distance from the centroid of the Census tract to the station (as calculated by the MPO over the regional highway network)

F_{ST} is the fare from the station ST to the CBD

P_{ST} is the expected parking cost at station ST

T_{ST} is ride time from station ST to the CBD

W_{ST} is the expected wait time for a train at station ST

T_{WST} is the average walk time from the station ST parking lots to the station ST

The parameters used in developing the station cost equations were described in Section III.

The V_{1T} coefficients shown below are calculated in the following fashion:

(11) $$.74\,T_{ST} + 1.65\,W_{ST} + 3.38\,T_{WST} = V_{1T}$$

for each station using the McFadden et. al. values of time for each component of transit use. The total transit costs for using each station are given as:

FERRY $1.625 + .6256998\,V_{1T} + .1574\,D_{FX} + 2\,V_{1T_1}\,T_{FX}$

COLLINGSWOOD $2.096 + .5984195\,V_{1T} + .1574\,D_{CX} + 2\,V_{1T_1}\,T_{CX}$

WESTMONT $2.0698 + .6623998\,V_{1T} + .1574\,D_{WEX} + 2\,V_{1T_1}\,T_{WEX}$

HADDONFIELD $2.0639 + .7139865\,V_{1T} + .1574\,D_{HX} + 2\,V_{1T_1}\,T_{HX}$

WOODCREST $2.55 + .7868598\,V_{1T} + .1574\,D_{WOX} + 2\,V_{1T_1}\,T_{WOX}$

ASHLAND $2.4472 + .8250467\,V_{1T} + .1574\,D_{AX} + 2\,V_{1T_1}\,T_{AX}$

LINDENWOLD $2.4464 + .9859198\,V_{1T} + .1574\,D_{LX} + 2\,V_{1T_1}\,T_{LX}$

where T_{iX} is the time from station i = F,C,WE,H,WO,A,L to Census Tract X as calculated by the MPO over their regional highway network.

APPENDIX B

LINDENWOLD LINE STATION USE BY CENSUS TRACT

TRACT	FERRY	C'WOOD	W'MONT	HDFD	WDCT	A'LND	LNWD	TOTAL
BURLINGTON COUNTY								
700102	7	3	0	0	0	2	1	13
700103	4	0	2	0	0	0	0	6
700104	3	0	1	0	0	1	0	5
700200	11	1	0	2	0	0	1	15
700303	4	0	2	0	0	0	1	7
700304	7	4	1	0	0	0	0	12
700305	30	4	7	1	0	0	0	42
700306	18	1	1	1	0	1	1	23
700307	18	0	3	2	0	0	1	24
700401	3	6	3	1	0	1	0	14
700402	5	12	11	4	0	0	1	33
700403	2	12	3	5	0	0	3	25
700405	1	6	7	3	0	0	1	18
700406	7	9	17	33	1	3	1	71
700501	12	8	11	11	2	3	4	51
700502	4	4	3	2	0	1	0	14
700503	8	7	5	9	1	0	0	30
700504	2	4	5	10	2	1	1	25
700505	2	1	4	2	0	0	0	9
700602	9	0	1	0	0	0	0	10
700603	8	1	1	0	1	0	0	11
700605	30	1	2	2	0	0	0	35
700701	1	0	0	0	0	0	0	1
700703	1	0	0	0	0	0	0	1
700800	3	1	0	0	0	0	0	4
700900	5	0	1	0	0	0	1	7
701001	1	0	0	2	0	0	0	3
701002	8	0	0	1	0	0	1	10
701102	1	0	0	0	0	0	0	1
701103	1	0	0	1	0	1	2	5
701104	1	0	0	0	0	1	2	4
701105	1	0	1	2	0	0	0	4
701203	0	0	0	1	0	0	0	1
701204	1	0	0	0	0	0	0	1
701205	1	1	0	0	0	0	0	2
701301	2	1	2	0	0	0	0	5
701302	0	0	0	1	0	0	1	2
701303	0	0	0	1	0	0	0	1
701400	0	0	1	0	0	0	0	1
701700	4	0	1	4	1	0	0	10
702000	0	0	0	1	1	0	0	2
702203	0	0	0	2	0	1	0	3
702204	1	0	0	0	0	0	1	2
702205	1	0	0	1	0	1	0	3
702208	0	0	0	2	0	1	0	3
702300	1	0	0	0	1	0	2	4
702400	0	0	1	2	0	0	0	3

702500	0	0	0	2	2	0	0	4
702601	2	2	2	4	1	1	0	12
202602	2	0	2	0	0	0	1	5
702603	0	0	0	1	0	0	0	1
702604	0	1	0	1	0	1	0	3
702700	0	0	1	5	3	2	0	11
702801	2	0	0	1	2	0	0	5
702802	4	0	1	0	0	0	0	5
702803	2	1	0	2	0	2	0	7
702804	1	0	4	1	1	2	1	10
702805	5	2	0	1	1	2	2	13
702806	4	1	2	1	0	0	0	8
702807	3	0	0	1	0	0	1	5
702808	5	0	0	1	0	0	0	6
702809	7	0	2	0	0	0	0	9
702810	6	0	0	1	2	2	0	11
702811	6	0	1	5	0	2	0	14
702903	8	2	3	13	10	7	1	44
702904	11	9	9	21	6	8	6	70
702905	9	8	6	28	10	8	1	70
702906	0	3	5	18	2	0	2	30
703000	0	1	2	2	0	1	1	7
703101	0	0	1	0	1	0	0	2
703102	0	0	1	1	1	0	0	3
703201	0	0	0	0	0	3	1	4
703202	0	0	0	2	0	1	0	3
703203	1	1	1	1	0	6	0	10
703600	2	1	0	3	0	6	10	22
703700	1	0	4	0	0	18	21	44
703801	0	1	0	6	2	23	2	34
703802	0	0	1	1	0	4	1	7
703803	2	2	3	9	0	69	14	99
703804	3	3	0	2	1	44	18	71
703900	1	3	2	6	1	35	12	60
704003	3	0	7	9	1	30	7	57
704004	2	0	4	5	1	23	4	39
704005	1	0	6	31	2	23	3	66
704006	0	0	0	3	2	0	3	8
704007	1	0	2	8	1	34	9	55
704008	0	0	2	3	0	40	11	56
704009	1	0	0	2	2	16	2	23
704010	0	3	3	2	1	19	23	51
TOTAL	324	131	174	312	66	450	183	1640

GLOUCESTER COUNTY

500100	48	0	10	3	0	0	5	66
500200	49	2	5	1	0	1	5	63
500300	10	0	2	2	7	0	0	21
500400	16	0	0	0	0	0	1	17
500500	21	1	1	1	0	0	0	24
500600	16	1	0	1	0	0	0	18
500700	93	3	4	6	1	13	36	156

500800	44	2	5	4	0	5	2	62
500900	28	0	0	0	0	0	1	29
501000	116	5	7	2	3	5	7	145
501100	56	3	1	8	1	15	9	93
501200	94	5	3	5	1	16	53	177
501300	24	2	0	1	1	6	8	42
501400	16	0	1	1	0	3	8	29
501500	8	0	0	2	1	2	2	15
501601	5	1	0	1	0	0	22	29
501602	9	0	1	0	0	1	21	32
501700	6	0	6	1	0	6	9	28
501800	4	0	0	2	0	0	4	10
502000	7	0	0	0	1	0	1	9
502300	22	1	0	0	0	1	1	25
502400	1	0	0	1	0	0	0	2
TOTAL	693	26	46	42	16	74	195	1092
CAMDEN COUNTY								
600200	7	1	0	2	0	0	0	10
600300	1	0	0	0	0	0	0	1
600400	3	1	0	1	0	0	0	5
600600	0	2	0	0	0	0	0	2
600700	0	0	0	0	0	1	0	1
600800	0	1	0	1	0	0	0	2
600900	1	0	0	0	0	0	0	1
601000	4	1	0	0	0	0	1	6
601100	6	0	0	1	0	0	2	9
601200	10	1	1	0	0	0	0	12
601300	11	1	0	0	0	1	1	14
601400	20	0	0	0	0	0	5	25
601500	37	2	0	0	0	0	2	41
601600	14	0	0	0	0	0	0	14
601700	12	0	0	0	0	0	1	13
601800	3	0	0	1	0	0	0	4
601900	16	0	0	0	0	0	0	16
602000	68	4	0	1	0	0	0	73
602501	5	7	1	0	0	0	0	13
602502	3	1	0	0	0	0	0	4
602503	22	2	0	1	0	1	0	26
602601	23	19	6	1	0	1	1	51
602602	21	8	3	0	0	2	0	34
602701	0	0	0	0	1	0	0	1
602702	16	10	6	2	0	0	1	35
602703	9	6	3	1	0	0	0	19
602800	4	0	1	0	0	0	0	5
602901	14	7	7	2	0	0	4	34
602902	11	10	11	1	0	0	2	35
603001	19	16	5	0	0	0	2	42
603002	14	7	2	1	0	1	1	26
603100	7	25	11	1	1	0	0	45
603200	6	18	31	13	0	0	4	72
603301	3	7	50	32	1	1	2	96

603302	16	4	57	51	0	4	4	136
603303	2	3	24	18	2	0	2	51
603400	3	2	39	116	2	2	5	169
603501	0	2	20	49	25	26	7	129
603502	4	1	19	58	18	196	37	333
603503	3	1	21	33	39	81	14	192
603504	1	0	5	6	36	50	2	100
603505	5	2	1	6	31	108	9	162
603601	4	0	38	103	14	8	4	171
603602	1	0	19	77	5	5	2	109
603603	1	0	16	81	5	2	2	107
603700	3	5	21	52	3	0	7	91
603800	7	63	56	8	0	1	3	138
603901	11	24	109	7	0	1	1	153
603902	5	16	16	1	0	0	2	40
604000	8	2	3	1	0	0	0	14
604100	28	0	1	0	0	0	0	29
604200	43	59	2	1	0	5	1	111
604300	17	105	3	2	1	1	4	133
604400	31	100	3	1	0	1	3	139
604500	29	28	3	2	0	1	3	66
604600	10	51	3	1	0	1	3	69
604700	22	47	5	1	0	0	2	77
604800	5	2	1	0	0	0	1	9
604900	23	3	2	0	1	0	0	29
605000	10	1	0	1	0	1	0	13
605100	21	2	1	1	0	0	1	26
605200	21	1	1	0	0	1	0	24
605300	14	2	3	0	0	0	0	19
605400	20	0	14	11	0	0	3	48
605500	8	3	13	1	0	0	0	25
605601	6	10	25	6	0	0	3	50
605602	8	9	50	5	1	1	1	75
605700	7	25	69	17	0	1	4	123
605800	7	0	40	20	0	3	1	71
605900	5	3	41	32	0	0	2	83
606000	5	2	41	30	1	0	0	79
606100	0	3	51	41	0	3	3	101
606200	4	2	103	58	1	3	4	175
606300	0	0	6	32	0	1	3	42
606400	1	4	17	103	0	1	0	126
606500	6	0	3	46	4	30	3	92
606600	1	1	11	62	0	2	1	78
606700	2	6	28	74	1	3	5	119
606800	14	0	7	28	1	1	1	52
606901	24	0	16	8	0	1	1	50
606902	0	0	0	1	0	0	0	1
607000	43	1	13	10	0	1	0	68
607100	14	3	6	20	0	18	3	64
607200	11	1	9	36	1	22	3	83
607300	0	2	3	9	4	128	11	157
607401	2	0	3	2	1	62	13	83
607402	1	1	0	1	1	47	24	75
607500	2	1	10	14	7	272	191	497

607600	0	0	1	1	1	4	70	77
607700	10	1	7	8	2	10	440	478
607800	5	1	3	3	1	7	230	250
607900	7	5	2	2	0	14	189	219
608001	3	1	1	2	1	4	84	96
608002	2	2	1	0	1	3	208	217
608100	1	0	1	1	1	12	13	29
608201	6	2	3	4	3	223	35	276
608202	2	0	0	0	0	7	3	12
608203	14	3	0	1	1	18	93	130
608204	0	0	1	0	0	0	0	1
608301	9	2	5	3	0	25	23	67
608302	16	1	1	7	1	20	4	50
608400	6	1	1	0	0	1	76	85
608500	1	0	4	2	3	5	201	216
608600	13	4	2	7	3	12	405	446
608700	1	1	1	1	0	2	151	157
608800	1	0	2	0	1	0	134	138
608901	1	0	1	0	1	1	64	68
608902	0	0	0	0	0	0	35	35
608903	0	0	0	2	1	4	76	83
609000	1	0	0	0	0	0	41	42
609101	0	0	0	1	0	2	88	91
609200	9	2	1	1	0	5	117	135
610200	2	0	1	0	0	0	1	4
TOTAL	1039	786	1248	1452	229	1482	3209	9445
TOTAL ALL THREE COUNTIES	2056	943	1468	1806	311	2006	3587	12177

APPENDIX C

DETAILED STATISTICAL RESULTS FROM SECTION V

Variable	Coefficient	t Statistic	F Value
Intercept	33,053	1.53	
Distance to BF Bridge	-5,392	-3.06	9.36
Distance to WW Bridge	4,275	1.98	3.93
Lot Size	.1568	4.79	22.92
Property Tax	13.18	6.32	39.97
Garage	7,492	3.18	10.10
Fireplace	8,277	3.51	12.31
One Bathroom	-15,510	-3.96	15.70
One & One Half Bathrooms	-13,518	-4.17	17.37
Savings	443	2.30	5.27

R^2 = .4177 F Statistic = 12.93

BIBLIOGRAPHY

Allen, W.B., The Impact of the Philadelphia-Lindenwold Rapid Transit Line on Automobile Traffic, Traffic Quarterly, Vol. XXVIII, No. 1, January, 1974, pp. 21-35.

Allen, W.B. and R. Mudge, A Technique to Assess the Micro-Impact of a Transportation Investment, Appraisal Journal, Vol. XLIII, No. 2, April, 1975, pp. 274-292.

Allen, W.B. and R. Mudge, The Impact of Rapid Transit on Urban Development: The Case of the Philadelphia-Lindenwold High Speed Line, in J. Bergsmann and H. Wiener (ed.), Urban Problems and Public Policy Choices, Praeger Publishers, New York, NY, 1975, pp. 294-311.

Allen, W.B. and D. Boyce, Impact of a High Speed Rapid Transit Facility on Residential Property Values, Proceedings of the International Conference on High Speed Ground Transportation, High Speed Ground Transportation Journal, Vol. 8, No. 2, 1974, pp. 53-60.

Alonso, William, Location and Land Use, Harvard University Press, Cambridge, MA., 1964.

Anas, Alex, The Impact of Transit Investment on Housing Value: A Simulation Experiment, Environment and Planning A, Vol 11, 1979, pp. 239-255.

Anas, Alex, Evaluating the Effects of Transportation-Land Use Policies on Housing Values and Household Welfare, Environment and Planning A, Vol 12, 1980, pp. 747-764.

Anas, Alex and Gun Lee, The Potential for a Value Capture Policy to Finance Rapid Transit Projects on Chicago's Southwest Side: An Empirical Simulation Analysis, Research in Urban Economics, Vol.2, 1980.

Anas, Alex, The Effects of Transportation on the Tax Base and Development of Cities, DOT/OST/P-30/85/005, April, 1983, USDOT, DOT-RC-92028.

Anderson, A.C., The Effect of Rapid Transit on Property Values, Appraisal Journal, Vol. 38, 1970, pp. 59-68.

Anderson, Robert and Thomas Crocker, Air Pollution and Residential Property Values, Urban Studies, Vol. 8, No. 1, 1976, pp. 1-13.

Beckmann, Martin, On the Distribution of Urban Rent and Residential Density, Journal of Economic Theory, Vol. 1, 1969, pp. 60-67.

Bijac, Vladimar, The Effects of a New Subway Line on Housing Prices in Metropolitan Toronto, Urban Studies, Vol 2, #2, May, 1983.

Boyce, David and W. Bruce Allen et al, Impact of Rapid Transit on Suburban Residential Property Values and Land Development, Phase One Report to the Office of the Secretary, USDOT, Nov, 1972.

Boyce, D. and W.B. Allen et al, Impact of Access Distance and Parking Availability on Suburban Rapid Transit Station Choice, U.S. Government Clearinghouse, Springfield, VA, PB-220694, 1973.

Boyce, D. and W.B. Allen, Impact of Rapid Transit on Suburban Residential Development: Analysis of the Philadelphia-Lindenwold High Speed Line, in Thomas P. Norman (ed.), New Jersey Trends: Population and Economy, Natural Resources, Housing, Transportation, Energy, Institute for Environmental Studies, Rutgers University, New Brunswick, NJ, 1974, pp. 478-497.

Boyce, D., W.B. Allen, and F. Tang, Impact of Rapid Transit on Residential Property Sales Price, in M. Chatterji (ed.) Space, Location, and Regional Development, Pion Limited, London, 1976, pp. 145-153.

Button, K. J., Transport Investment and Urban Land Values: A Comment, International Journal of Transport Economics, Vol. 9, no. 4, 1982, pp. 349-354.

Capozza, Dennis, Measuring the Benefits of Urban Improvements, paper presented at the Winter Econometric meetings, Toronto, 1972.

Capozza, Dennis, Subways and Land Use, Environment and Planning, Vol 5, 1973, pp. 555-576.

Capozza, Dennis, Land Use in a City with Two Modes of Transportation, Southern Economic Journal, 1973, pp. 442-449.

Carpenter, J.C., Transferable Development Rights Applied to Value Capture, paper presented at the Fourth Intersociety Conference on Transportation in Los Angeles, July 23, 1976.

Casetti, E., Equilibrium Land Values and Population Densities in an Urban Setting, Economic Geography, Vol. 47, 1971, pp. 16-20.

Congressional Budget Office, The Federal Budget for Public Works Infrastructure, U.S. Government Printing Office, Washington, DC, July, 1985.

Czamanski, S., Effects of Public Investment on Urban Land Values, Journal of the American Institute of Planners, Vol. 32, 1966, pp. 204-217.

Damm, David, Steven Lerman, et al, Response of Urban Real Estate Values in Anticipation of the Washington Metro, Journal of Transport Economics and Policy, Sept, 1980, pp. 315-336.

Dewees, Donald, The Effect of a Subway on Residential Property Values in Toronto, Journal of Urban Economics, Vol 3, #4, 1976, pp. 357-369.

Echenique, M., Transport Investment and Urban Land Values, International Journal of Transport Economics, Vol. 8, 1981, pp. 189-211.

Falcke, Caj, BART's Effects on Property Prices and Rents, BART Impact Program, WP-52-5-78, Berkeley, Metropolitan Transportation Commission, 1978.

Falcke, Caj, Methodologies for Assessing the Impacts of Major Transportation Facilities on Land Use and Land Prices, TSC, USDOT, Cambridge, 1982.

Ferguson, Bruce, Michael Goldberg, and Jonathan Mark, The Pre-Service Impacts of the Vancouver Advanced Light Rail Transit System on Single Family Property Value, unpublished paper, University of British Columbia, December, 1984.

Fetter, F.A., The Economic Law of Market Areas, Quarterly Journal of Economics, Vol. 38, 1924, pp. 520-529.

Fisch, Oscar, The Accuracy of Changes of Urban Land Values as a Measure of Social Benefits from Public Programs, Regional Science and Urban Economics, Vol 10, 1980, pp. 473-489.

Freeman, A. Myrick, Spatial Equilibrium, the Theory of Rents, and the Measurement of Benefits from Public Programs: A Comment, Quarterly Journal of Economics, Vol. 88, 1975, pp. 470-473.

Goldberg, Michael, Transportation, Urban Land Values, and Rents: A Synthesis, Land Economics, Vol. XLVI, No. 2, May 1970, pp. 153-162.

Goldberg, Michael, An Evaluation of the Interaction Between Urban Transport and Land Use Systems, Land Economics, Vol. XLVIII, No. 4, November 1972, pp. 338-346.

Goldstein, G.S., and Leon Moses, Transportation Controls and the Spatial Structure of Urban Areas, American Economic Review Papers and Proceedings, Vol. 65, 1975, pp. 289-294.

Grether, D. and P. Mieszkowski, Determinants of Real Estate Values, Journal of Urban Economics, Vol. 1, 1974, pp. 127-146.

Hagman, D. and D. Misczynski, Windfalls for Wipeouts: Land Value Capture and Compensation, American Society of Planning Officials, Chicago, 1978.

Hartwick, P.G. and J.M. Hartwick, An Analysis of an Urban Thoroughfare, Environment and Planning, Vol 4, 1972, pp. 193-204.

Heenan, G. Warren, The Economic Effect of Rapid Transit on Real Estate Development, Appraisal Journal, April 1968, pp. 213-224.

Hochman, O. and D. Pines, Competitive Equilibrium of Transportation and Housing in the Residential Ring of an Urban Area, Environment and Planning, Vol 3, 1971, pp. 51-62.

Howard, J.A., G. Rivkin, S. Brecher, and L. Heder, Strategies to Implement Benefit Sharing for Fixed Transit Facilities, National Cooperative Transit Research and Development Program, Report 12, Transportation Research Board, National Research Council, Washington, DC, July, 1985.

Hyson, C.D. and W.P. Hyson, The Economic Law of Market Areas, Quarterly Journal of Economics, Vol. 64, 1950, pp. 319-325.

Kain, J.R. and J.M. Quigley, Measuring the Value of Housing Quality, Journal of the American Statistical Association, Vol. 65, 1970, pp. 532-548.

Knight, Robert and Lisa Trygg, Evidence of Land Use Impacts of Rapid Transit Systems, Transportation, Vol 6, 1977, pp. 231-247.

Lave, L., Congestion and Urban Location, Papers of the Regional Science Association, Vol. 25, 1970, pp. 133-150.

Lee, Douglas B. et al, Impact of BART on Prices of Single Family Residences. Institute of Urban and Regional Development, Berkeley, University of California, 1973.

Lee, Douglas B. and C.P. Averous, Land Use and Transportation: Basic Theory, Environment and Planning, Vol 5, 1973, pp. 491-502.

LeRoy, Stephen and Jon Sontelie, Paradise Lost and Regained: Transportation Innovation, Income, and Residential Location, Journal of Urban Economics, Vol 13, 1983, pp. 67-89.

Lind, R.C., Spatial Equilibrium, the Theory of Rents, and the Measurement of Benefits from Public Programs, Quarterly Journal of Economics, Vol 87, May, 1973, pp. 188-207.

Lind, R.C., Reply, Quarterly Journal of Economics, Vol. 88, 1975, pp. 474-476.

McFadden, Daniel, Antii Talvitie, and Associates, Urban Travel Demand Forecasting Project-Final Report, Institute of Transportation Studies, University of California at Berkeley, 1977.

Mohring, Herbert, Land Values and the Measurement of Highway Benefits, Journal of Political Economy, Vol 79, 1961, pp. 236-249.

Mohring, H. and M. Harwitz, Highway Benefits, Northwestern University Press, Evanston, IL., 1962.

Moses, Leon, class lectures in C-53 Location Theory, Northwestern University, Department of Economics, Evanston, IL, 1965.

Muth, R., Economic Change and Rural Urban Land Conversions, Econometrica, Vol. 29, 1961, pp. 1-23.

Muth, R., Cities and Housing, University of Chicago Press, Chicago, IL , 1969.

Niedercorn, J., A Negative Exponential Model of Urban Land Use Densities and Its Implication for Metropolitan Development, Journal of Regional Science, Vol. 11, 1971, pp. 317-326.

Pendleton, W.C., Relation of Highway Accessibility to Urban Real Estate Value, Highway Research Record, Vol. 16, 1963, pp. 14-23.

Pines, David and Yoram Weiss, Land Improvement Projects and Land Values, Journal of Urban Economics, Vol 3, No. 1, 1976, pp. 1-13.

Pines, David and Yoram Weiss, Land Improvement Projects and Land Values: An Addendum, Journal of Urban Economics, Vol 11, 1982, pp. 199-204.

Oron, Yitzhak, David Pines, and Eytan Sheshinski, The Effect of Nuisances Associated with Urban Traffic on Suburbanization and Land Values, Journal of Urban Economics, Vol 4, 1974, pp. 382-394.

Rice Center for Community Design and Research, A Value Capture Study, United States Department of Transportation, four volumes, Washington, DC, November, 1974.

Rice Center for Community Design and Research, Value Capture and Joint Development Applications: Los Angeles, Louisville, Chicago, United States Department of Transportation, Washinngton, DC, 1976.

Rothenberg, Jerome, Urban Renewal Programs in Robert Dorfman, ed., Measuring the Benefits of Government Investment, Brookings, Washington, D.C., 1965.

Schall, L., A Note on Externalities and Property Valuation, Journal of Regional Science, Vol. 11, 1971, pp. 101-106.

Shaw, E.A., Rail Transportation's Effect upon Real Estate Values, Appraisal Journal, Vol. 37, 1969, pp. 532-537.

Southern California Rapid Transit District, Joint Development and Value Capture in Los Angeles: Local Policy Formulation, USDOT Report, I-83-23, Washington, DC, January, 1983.

Spengler, E.H., Land Values in New York in Relation to Transit Facilities, Columbia University Press, New York, NY, 1930.

Strotz, Robert H., The Measurement of Benefits, unpublished paper, Department of Economics, Northwestern University, Evanston, IL, March 31, 1966.

Strotz, Robert H., Urban Transportation Parables, in J. Margolis, ed., The Public Economy of Urban Communities, Johns Hopkins Press, Baltimore, 1965, pp. 127-169.

The Urban Institute, Toward Rational Road User Charges, Working Paper 5044-4, Washington, D.C, October, 1976.

Von Thunen, J., Der Isolirte Staat in Beziehung Auf Landwirthschaft Und National Okonomie, Wiegandt, Berlin, 1836.

Wabe, Stuart, A Study of House Prices as a Means of Establishing the Value of Journey Time, the Rate of Time Preference, and the Valuation of Some Aspects of Environment in the London Metropolitan Region, Applied Economics, Vol. 3, 1971, pp. 247-255.

Walters, A.A., The Economics of Road User Charges, The Johns Hopkins University Press, Baltimore, MD, 1969.

Wheaton, William, Residential Decentralization, Land Rents, and the Benefits of Urban Transportation Investment, American Economic Review, March, 1977, pp. 138-143.

Wingo, Lowdon, Transportation and Urban Land, Resources for the Future, Washington, 1961.